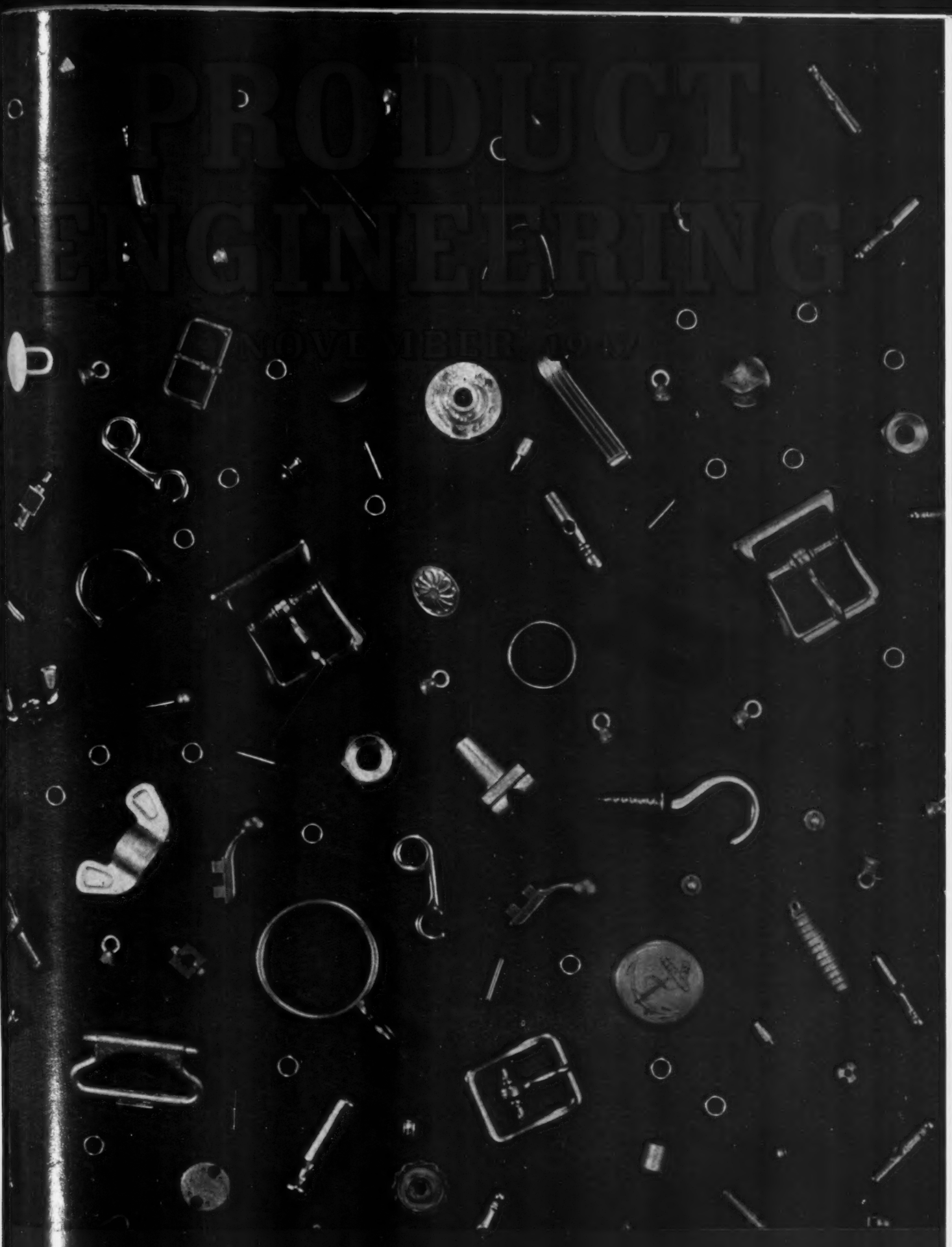
PRODUCT ENGINEERING

NOVEMBER 1960



IN THIS ISSUE ✦ Small Fine Alloy Die Castings ✦ Thermostat Controls ✦ Specialized Aluminum ✦ Duplex Characteristics ✦ Engineering Standards ✦ Disk Flywheels

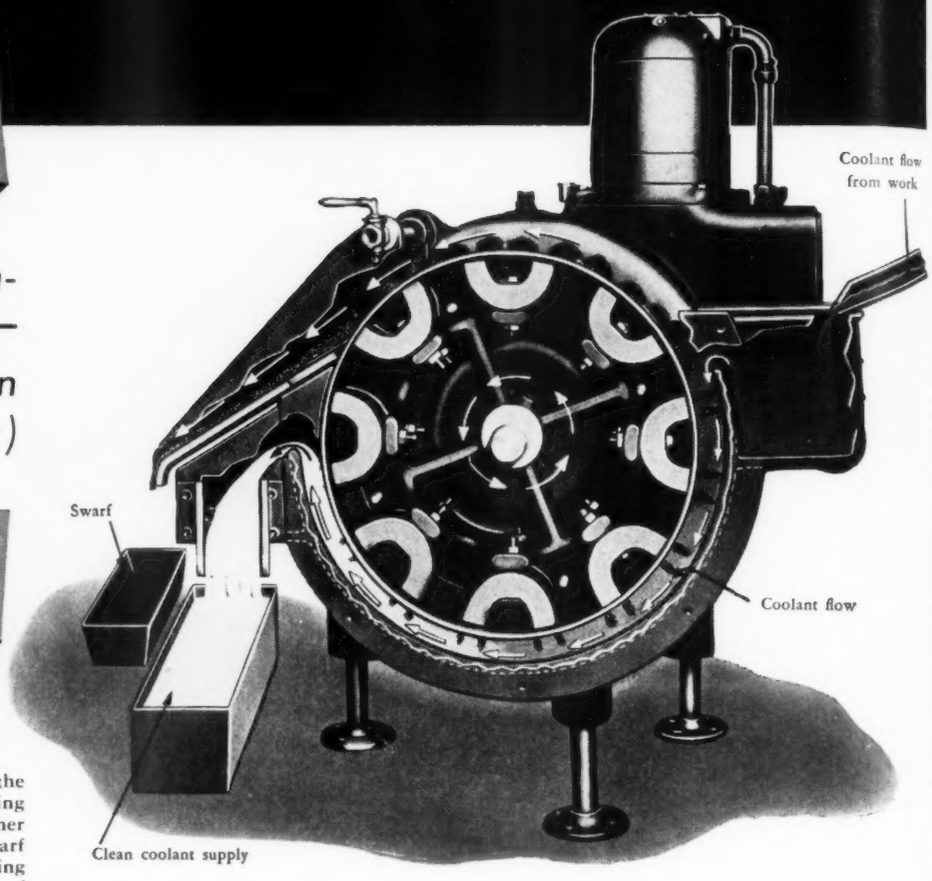
A McGRAW-HILL PUBLICATION

Cutting Oils Re-claimed Automatically...

with the help of...

ALNICO MAGNETS

(Aluminum-NICKEL—Cobalt—Iron Alloy)



BARNESDRIL AUTOMATIC MAGNETIC COOLANT SEPARATOR . . . pictured to show operation. Coolant from the work flows, as pictured, around a revolving drum that carries Alnico magnets on its inner face. On its outer face, the magnetic swarf fastens endwise over each magnet. Traveling with the drum toward a scraper, the swarf fine-combs most of the other entrained non-magnetic particles from the coolant. Standard sizes handle 5, 10, 20, 40 or 100 gal. per min.

Here's an open view of a separator that completely frees machine operators from the task of keeping coolants clean.

Fully automatic, this type reclaims as much as 100 gallons of oil per minute.

Developed and produced by Barnes Drill Co. of Rockford, Ill., the equipment incorporates a series of Alnico permanent magnets containing 20 per cent Nickel, which contribute fundamentally to the unique efficiency of this separator.

The exceptionally high magnetic properties of Alnico, an aluminum-Nickel-cobalt-iron alloy, permit designs that were technically impossible with older materials. Compared with the latter, Alnico reduces space and weight requirements to practical limits.

Nickel, an essential element in Alnico, also improves hundreds of other alloys for applications in the machine tool industry.

We invite consultation on the use of Nickel or Nickel alloys in your products or equipment.

EMBLEM OF INCO SERVICE
TRADE MARK

Over the years, International Nickel has accumulated a fund of useful information on the selection, fabrication, treatment and performance of engineering alloy steels, stainless steels, cast irons, brasses, bronzes and other alloys containing Nickel. This information is yours for the asking. Write for "List A" of available publications.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

G. F. Nordenholt.....Editor
Joseph Kerr.....Assistant to the Editor

Hendley Blackmon.....Managing Editor

J. R. Bright.....Associate Editor
Harold Schor.....Associate Editor
Stuart P. Hall.....Associate Editor
R. A. Wason.....Assistant Editor
Ernest W. Schlieben.....Assistant Editor
N. J. Van Ness.....Assistant Editor

Donald D. Hogate.....Washington
R. E. Bruckner.....Consulting Editor

Albert Hauptli, Jr.....Publisher
W. E. Kennedy.....Assistant Publisher

DISTRICT MANAGERS

John H. Koch, Boston; P. G. Weatherby, Boston; J. A. McGraw, New York; Hugh Britton, New York; Richard Y. Fuller, Philadelphia; Ray Deen, Chicago; Anson E. Meanor, Chicago; A. F. Tischer, Cleveland; R. H. Anderson, Cincinnati; David G. Jones, Detroit; R. M. Maultsby, Atlanta; R. N. Phelan, Los Angeles; J. W. Otterson, San Francisco.

McGRAW-HILL
PUBLISHING CO., INC.
Executive and Editorial Offices
330 WEST 42nd STREET, NEW YORK, N. Y.

James H. McGraw, Founder and Honorary Chairman; James H. McGraw, Jr., President; Curtis W. McGraw, Senior Vice-President and Treasurer; Joseph A. Gerardi, Secretary; Nelson Bond, Director of Advertising; Eugene Duffield, Editorial Assistant to the President; J. E. Blackburn, Jr. Director of Circulation.

PUBLICATION OFFICE: 99-129 NORTH BROADWAY, ALBANY 1, N. Y. RETURN POSTAGE GUARANTEED. EDITORIAL AND EXECUTIVE OFFICES: 330 W. 42nd St., NEW YORK 18. Branch Offices: 520 N. Michigan Ave., Chicago 11; 68 Post St., San Francisco 4; National Press Bldg., Washington 4; Architects Bldg., 17th & Sansom Sts., Philadelphia 3; 738-9 Oliver Bldg., Pittsburgh 22; 1510 Hanna Bldg., Cleveland 15; 2080 Penobscot Bldg., Detroit 26; Continental Bldg., St. Louis 8; 1427 Statler Bldg., Boston 16; 1011 Rhodes-Haverty Bldg., Atlanta 3; 622 S. Hope St., Los Angeles 14; Aldwych House, Aldwych, London, W.C. 2, England.
PRODUCT ENGINEERING Copyright 1947 by McGraw-Hill Publishing Co., Inc. All rights reserved.
Published monthly. Price 75c per copy. Allow at least ten days for change of address. Communications about subscription should be addressed to Director of Circulation PRODUCT ENGINEERING, 330 West 42nd St., New York 18. Indicate position and company connection on all subscription orders. Subscription rates: United States and possessions, $6 for one year, $9 for two years, $12 for three years. Canada, $7 for one year, $11 for two years, $14 for three years. Latin American countries, $10 for one year, $16 for two years, $20 for three years. All other countries, $15 for one year, $25 for two years, $30 for three years. Entered as second-class matter August 21, 1936, at Post Office, Albany, N. Y., under the act of March 3, 1879. Printed in U.S.A. Cable Address: "McGraw-Hill, New York." Member A.B.P., A.B.C.

PRODUCT ENGINEERING

Volume 18 Number 11

NOVEMBER, 1947

Engineering and Manufacturing Standards 81
W. L. MATTHEW

Small Zinc Alloy Die Castings 86
JOSEPH SAKS

Product Designs 90

Silver and Copper Electrical Contacts 104
B. W. JONES AND L. L. ZICKRICK

Progress in Review 108

Spot-Welding Aluminum Lap Joints 112
ROBERT C. McMASTER AND HORACE J. GROVER

Industrial Adhesives—I 117
NICHOLAS J. DeLOLLIS

Applying Bimetal Thermostats 123
J. O. MOORHEAD

Variable Speed Transmissions—II 128

Remote Hydraulic Control 136
HARRY P. KUPIEC

Damping Characteristics of Dashpots 138
JOHN B. PETERSON

Flame-Cut Disk Flywheels 141

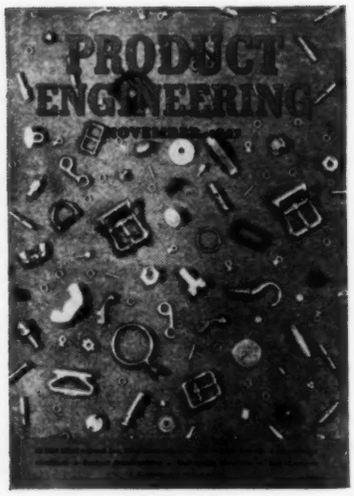
High Heat and Corrosion Resistant Plastic 154
EVERETT B. YELTON

Charpy and Izod Testing—II 159
C. M. SCHWITTER

Tables to Guide in the Selection of Materials—I 165
ZOLA FOX

Editorial 79
Engineering Abstracts 130
New Books 163
Technical News Highlights 144
Washington Notes 147
New Materials and Parts 171

IN THIS ISSUE



FRONT COVER

SMALL ZINC ALLOY die castings, each weighing less than one-half ounce, are illustrated in actual size. McGraw-Hill kodachrome, courtesy of Gries Reproducer Corporation.

Small Zinc Alloy Die Castings

Zinc alloy die castings, weighing less than one half ounce, offer many new design advantages. On page 86, Joseph Saks, Sales Manager, Gries Reproducer Corporation, discusses the economic and design advantages of small die cast parts. Tables of production cost comparisons and engineering design data are included.

Engineering and Manufacturing Standards

Duplication of work can often be avoided by the use of drawing standards, prescribed methods of computation and standard parts, in engineering design departments. On page 81, W. L. Matthew, Caterpillar Tractor Company, describes the formation and maintenance of an engineering standard system. Sample standards pages and forms used in the administration of the system are shown.

Thermostatic Temperature Control

Designers can usually obtain reliable and economical automatic control of temperature by the proper selection and application of simple bimetal thermostats. On page 123, J. O. Moorhead, Engineering Department, Spencer Thermostat Company, describes eight application considerations, current and voltage compensation, and typical performance characteristics of these components.

Damping Characteristics of Dashpots

The results of an investigation on the damping characteristics of dashpots conducted at the National Bureau of Standards are given on page 138, by John B. Peterson, now with the Naval Research Laboratory.

Flame-Cut Disk Flywheels

Design standards and design configurations for well known machine elements sometimes tend to become obsolete with the advent of new manufacturing techniques. This is illustrated by the gradual displacement of the rim-and-arm type flywheel by the disk type flywheel. On page 141, the design of both types is reviewed and supporting data are given to show that disk type wheels often are better than rim-and-arm type wheels.

Heat and Corrosion Resistant Plastic

Many applications as gaskets, seals and electrical components are forecast for a new thermoplastic material, polytetrafluoroethylene, tradenamed Teflon; its outstanding properties are extremely high resistance to all types of corrosive agents and to high operating temperatures. On page 154, E. B. Yelton, E. I. du Pont de Nemours & Company, discusses applications and characteristics of this new material.

Remote Hydraulic Control

Designers of control systems for hydraulic equipment will be interested in a new method for the control of remote hydraulic valves, which is claimed to have weight and cost savings. On page 136, Harry P. Kupiec, Air Associates, Inc., gives a brief description of the operation of this new system, and cost and weight comparisons with several other control systems.

Silver and Copper Electrical Contacts

Better understanding of their unusual electrical and metallurgical properties are leading to increasing use of silver and copper for electrical contacts. On page 104, B. W. Jones and L. L. Zickrick, General Electric Company, give a comparison of significant electrical and metallurgical characteristics of these materials. The current-resistance relationships of oxides, welding and arcing characteristics, and effects of heavy current on surface structure are discussed.

Industrial Adhesives—I

An ever widening range of industrial adhesives has led designers to consider this method of construction in many specialized applications. On page 117, Nicholas J. De Lollis, National Bureau of Standards, discusses vegetable, protein and thermoplastic resin types of adhesives in the first part of a two part series. Factors affecting bond strength and methods of surface preparation are covered.

Materials Application Tables

Designers are often faced with the necessity of using materials whose properties are unfamiliar to them. On page 165, Zola Fox, Engineer, Curtiss-Wright Corp., begins a presentation of data concerning materials used in machine design.

Spot Welded Aluminum Lap Joints

The lack of information on the behavior of spot welded aluminum alloy parts subjected to repeated loads, has been a source of concern for many designers. On page 112, Robert C. McMaster and Horace J. Grover of the Battelle Memorial Institute discuss a wartime test program which was conducted to determine the fatigue strength of typical spot welded aluminum alloy joints.

DECEMBER HIGHLIGHTS

Steel at Low Temperatures, by H. W. Gillett, chief technical advisor of Battelle Memorial Institute. Discussion of subzero cooling in steel treatment and structure service.

Accelerating Inertia Loads With a Varying Torque, by James D. Burby. Analysis of methods for calculating time required to accelerate rotating inertia loads.

Combating Motor Noise, by William O. Ordinanz of Brasov, Rumania. Analysis of magnetic, ventilating and mechanical factors that cause noise in motors.

Sealing Ceramic to Metal, by A. L. Jenny, Works Laboratory, General Electric Company. Promising simple seal that is easily applied to many designs now using gaskets.

PRODUCT ENGINEERING Editorial

NOVEMBER, 1947

Playing It Safe Is Often Dangerous

"PLAY IT SAFE" sounds like a sensible policy and therefore most people follow it. Many design engineers "play it safe" by the simple method of adding a little here and little there to the so-called "factors of safety." Thus they build up a sense of security concerning the adequacy of the design.

Too often the feeling of security produced by the use of high factors of safety is false. When the design is built and put to test the errors created by excessively high factors of safety come to light.

Factor of safety is aptly referred to as factor of ignorance. Aware of his lack of complete knowledge of the factors involved, the designer applies a more or less arbitrarily selected factor of safety. The smaller his confidence in his data and procedures, the bigger will be his factor of safety. Unfortunately, as a result of pyramiding factors of safety, the design sooner or later gets out of balance.

Perhaps one of the most frequently revealed mistakes caused by compounding factors of safety occurs in the determination of the electric motor horsepower required. In order to "play safe", the designer allows "a little extra" when estimating his weights, inertias and friction. He then calculates the maximum horsepower required at the peak of the cycle, which is usually at the moment of starting. Not being too sure of his estimates, he may add another fifty percent to the horsepower he calculated. He then specifies a motor of that horsepower, although the power required at running speed may be only a small fraction of that amount.

In allowing an additional fifty percent power for "unusual starting conditions" and specifying a motor of that size, the designer does not take into consideration that electric motors are rated and designed to carry a 200 percent overload for short periods. Thus in this example, a motor half as big in horsepower, or possibly even smaller, would be sufficient. The excessively large motor not only requires larger starting equipment but also runs at low efficiency and low power factor.

This elementary example of the ills of "playing it safe" is indicative of the danger of such a policy. The same philosophy applied to aircraft would result in planes that could not leave the ground. Applied to automobiles, it would result in cars resembling the 1900 vintage.

The way to "play it safe" is not to compound factors of safety but to establish reliable data, by tests if necessary, and then make careful and complete calculations, investigating thoroughly all the design features and possibilities. Factors of safety are not acceptable excuses for ignorance that breeds lack of design confidence. Used promiscuously, they lead to trouble.

G. F. Yodenholt

TWELVE HUNDRED HANDS TO FIND THE FACTS

FOUR hundred field correspondents ferret out, spade up, shoot in stories from all over the world of industry. Two hundred editors, bristling with Ph.D.'s and practical engineering and scientific knowledge, cull and correct and explain and expound. That's McGraw-Hill.

It *takes* a huge staff like this to keep abreast of events and developments in such a giant sphere as American industry. And the vote of thousands upon thousands of regular readers of McGraw-Hill publications seems to be: McGraw-Hill *has* what it takes to get the facts – fast.

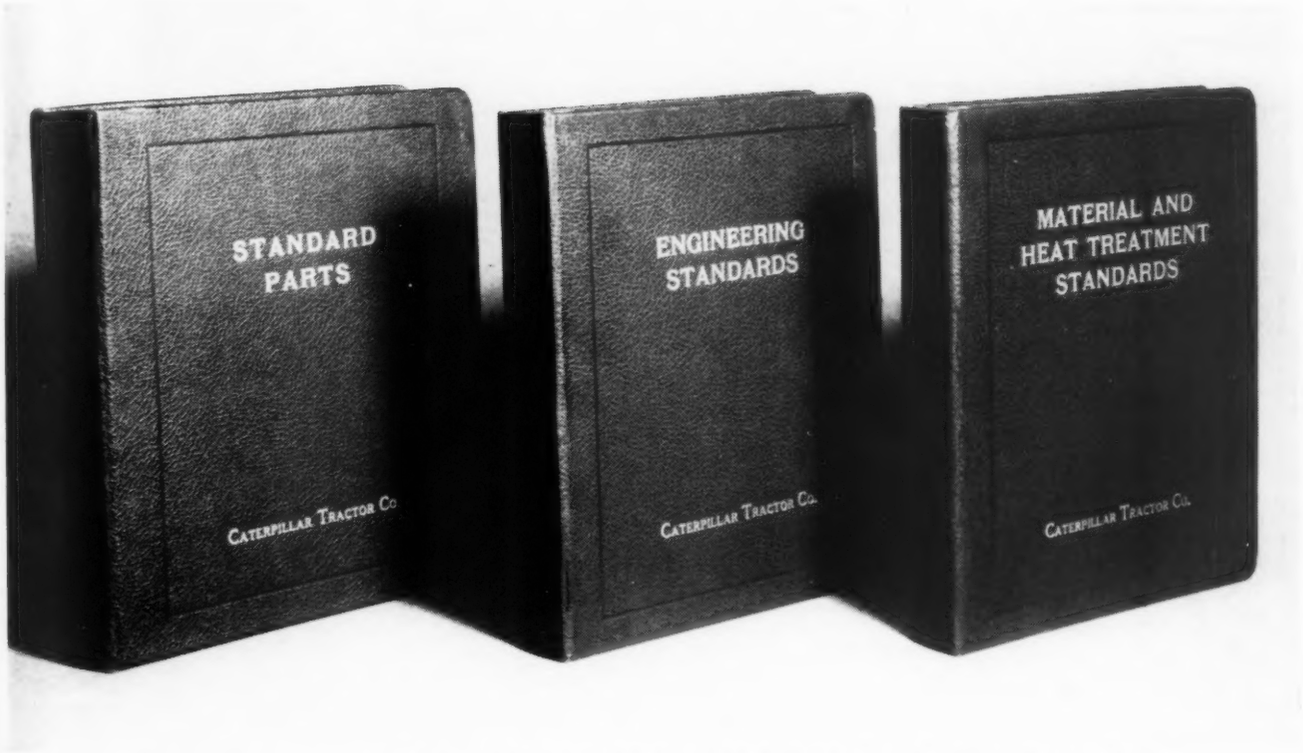
To be well versed in the latest developments in *your industry*, be a cover-to-cover McGraw-Hill reader. Editors *and advertisers* collaborate to make your job easier. The advertising pages of all McGraw-Hill publications are packed with newsworthy information . . . the latest news on products and services that contribute to profits.

McGRAW-HILL

Publishing Company, Inc., 330 West 42nd Street, New York 18, N. Y.

HEADQUARTERS FOR INDUSTRIAL INFORMATION

The McGraw-Hill Network of Industrial Communication: American Machinist • Air Transport • Aviation • Aviation News • Bus Transportation • Business Week • Coal Age • Chemical Engineering • Construction Methods • Electrical Contracting • Electrical Merchandising • Electrical West • Electrical Wholesaling • Electrical World • Electronics • Engineering & Mining Journal • E. & M. J. Metal and Mineral Markets • Engineering News-Record • Factory Management & Maintenance • Food Industries • McGraw-Hill Digest • Mill Supplies • Power • Product Engineering • Science Illustrated • Textile World • The Welding Engineer.



Three heavy seven-ring binders with plain black crackled finish give dignity to the standards.

Engineering and Manufacturing Standards

W. L. MATTHEW
Caterpillar Tractor Company

Formation and maintenance of an engineering standards system. The origin and preparation of new standards is described. Sample standards pages and forms used in the administration of the system are shown.

THE USE of drawing standards, prescribed methods of computations and standard parts in engineering design departments avoids much duplication of work and promotes the efficiency of departmental operations. Material and heat-treatment standards, ordered routine in fabrication and the use of standard parts reduce manufacturing and processing time.

The standards section of the Caterpillar Tractor Company has for its function the correlation of engineering standards to achieve uniform quality of product and to promote high over-all efficiency of engineering and manufacturing procedure. The standards section, consisting of a standards engineer and six assistants, is a part of the quality control division of the engineering department. In addition to the maintenance of three standards volumes, this section accumulates data for the preparation of revised standards and new standards, and drafts the standards sheets.

Material prepared by the standards section is classified for issue and filing in one of three volumes. Volume I, Standard Parts, contains lists of standard parts; up to date more than 50,000 standard parts are listed. Volume II, Engineering Standards, covers engineering and design data, and practices and forms for calculations. Volume III is the Material and Heat-Treatment Standards.

The Standard Parts Volume is maintained for the purpose of listing conveniently all parts that are used repeatedly in the design of new products or the revision of existing products. Included are parts such as bolts, gaskets and bushings that are purchased in large quantities, and special company-designed machined fittings, forged parts, springs and other parts that are commonly used.

The point of origin for all information appearing in this volume is the design checker's desk. The design checker is well acquainted with many designs and is the last person to work on the drawing of a part. Consequently, he is the logical person to initiate action. If, in his opinion, a part can be used to good advantage

Table I—Contents of Volume II Engineering Standards

Section	Subject of Section and Subdivisions
A	Index Items arranged alphabetically Table of contents A preface explaining the purpose of the Standards and how to use them
B	Drawing Practice Drafting room rules Procedure in making engineering drawings Sheet sizes, weight of lines Sectioning and screw thread representation Lettering, dimensioning Assignment of part numbers, explanatory notes Checking of drawings Method of releasing drawings Drawing revisions
C	Screw Threads History and development of screw threads Terminology, forms of threads, classes of fits Pitch diameter tables, standard stud fits 12 pitch series of threads Tables of dimensions of bolts and screws
D	Springs Definition of camber Type of drawings (as extension, compression and torsion) Spring ends, formulas for calculating springs Leaf-spring drawings and formulas Method of drawing a coil spring, snap springs Valve springs and wire for this type of spring Explanation of the Wahl factor Sizes and forms for spring data block Spring tables
E	Gears Backlash allowance charts Tables of chordal thickness Addenda and dedenda, other tooth proportions Information to be placed on gear drawings Formulas for computing gears Gearing tables and other data
F	Keys and Keyways Tables for cord height Formulas for both hard and soft keys "p" value of Woodruff Keys Description of types of keys Applications of keys
G	Dimensions and Fits Ball bearing fits, bolt clamp lever dimensions Head dimensions of bolts, cap screws, rivets, nuts, set screws Standard pin and dowel dimensions Malleable iron pipe fittings, shaft fits Splines, taper pins, wood screws
H	Tables Decimal equivalents of inches Decimal equivalent of millimeters Draft angle equivalents, gear pump capacities Grade chart, length of bends in sheet metal Standard tapers per foot and corresponding angles, wire gage tables
J	Company Procedures (design and manufacture) Items not yet in index or that do not lend themselves to indexing Bushing press-fit charts, hose and hose clamps Identification numbers on parts Machine centers, steel clamps 90 deg. taper spline formulas and sizes Vee-belts, design and layout
K	Miscellaneous Control rod assemblies, copper asbestos gasket Elongated holes in sheet metal Engineering letter numbers, gro shafts Instruction plate sizes, model n bers Tinned tubes, tube bends, wre formulas
L	Part Numbers Cross index list of part numbers commonly used standard parts. example, the part numbers of a n lockwasher, plain washer, cotter p are listed opposite thread size
M	Notes Space for expansion

Table II—Contents of Volume III Material and Heat-Treatment Standar

Section	Subject of Section and Subdivisions
A	Index Items arranged alphabetically Table of contents A preface explaining the purpose the Standards and how to use t
B	Material Specifications Complete list of material speci tions Drawing identifications, symbol Abbreviated description of material
C	Heat Treatment Annealing, carburizing, cyaniding Direct heat treatment Heat treatment specifications Induction hardening Method of specifying heat treatm Nitriding Nomenclature and purpose of h treating
D	Hardening Brinell hardness, Rockwell hard File and shore hardness, differen hardness

in future designs, it is his responsibility to suggest that the part be incorporated in the Standard Parts Volume. The checker's suggestion is made on a simple form (Fig. 1). He fills in all but the block headed "Follow-up." The form is then turned over to the standards section, which becomes responsible from then on.

If the part is used in an experimental design, the standards section does not place the part in the Standard Parts Volume immediately but waits until the part has been released for regular production. A check-up clerk is assigned to check on the status of the part at 7-day intervals. His checks are entered in the follow-up block of the checkers form. Over 90 percent of all parts proposed for standards are released to production within six weeks; hence the six spaces provided in the follow-up form are usually adequate. If a part remains in the experimental status longer than six weeks, another form is attached to the first and subsequent checks are made monthly instead of weekly.

When a check reveals that a part has been released for production, the follow-up clerk lists the part on the proper page in a master copy of the standard parts volume. The nature of the part determines the date of its insertion in the standard parts volume. If the part is commonly used it is entered quickly, otherwise some time may elapse before it is officially designated as a standard. Sometimes in order to prevent duplication in design, a standard parts supplement is issued, listing parts such as washers and studs. The purpose of the supplement is to relieve the standards section at times when there is a peak work load. The standards section then has additional time to make extensive revisions to standard part pages containing tabulated data.

In a standard parts volume containing thousands of individual parts, a distinction must be made between parts that are preferred for design and those that are not. Parts may be preferred because they are readily obtainable, economical, available from stock, or for other reasons. Preferred parts are indicated by heavy black print as shown on the sample page appearing in Fig. 2. All other parts, indicated by italic print, are restricted in use. Occasionally the use of a part may become so limited as to justify its re-

Hardness conversion table
Hardness specification classes
Carburized parts, steel castings
Purpose of hardness

E Castings
Iron casting specifications
Effects of alloys, finish
Heat treated casting
Chemical and physical properties of wire castings
Sample lugs, malleable iron castings
Markings of castings, standard notes
Steel castings

F Forgings
Classes of forging, forging drawings
Finish allowances and tolerances of hot pierced gear blanks
Heading dies
Markings on forging and machine drawings
Punching dies, standard notes

G Welding
Welding symbols, types of joints
Length of fillet welds to replace rivets
Low temperature brazing materials
Resistance welding
Allowable loads for fillet welds
Welding specifications

H Mill Tolerances
Bar size shapes, hot and cold rod
Carbon steel products
Bars and shafting alloy and carbon steel
Machine straightening, mild steel divisions
Nomenclature, seamless steel tubing
Specifications for hot finished flats
Tolerances of cold finished bars of all shapes
Weight per cubic inch steel

J Company 1E Summary
Various 1E Specifications

K Miscellaneous
L Space
M Notes

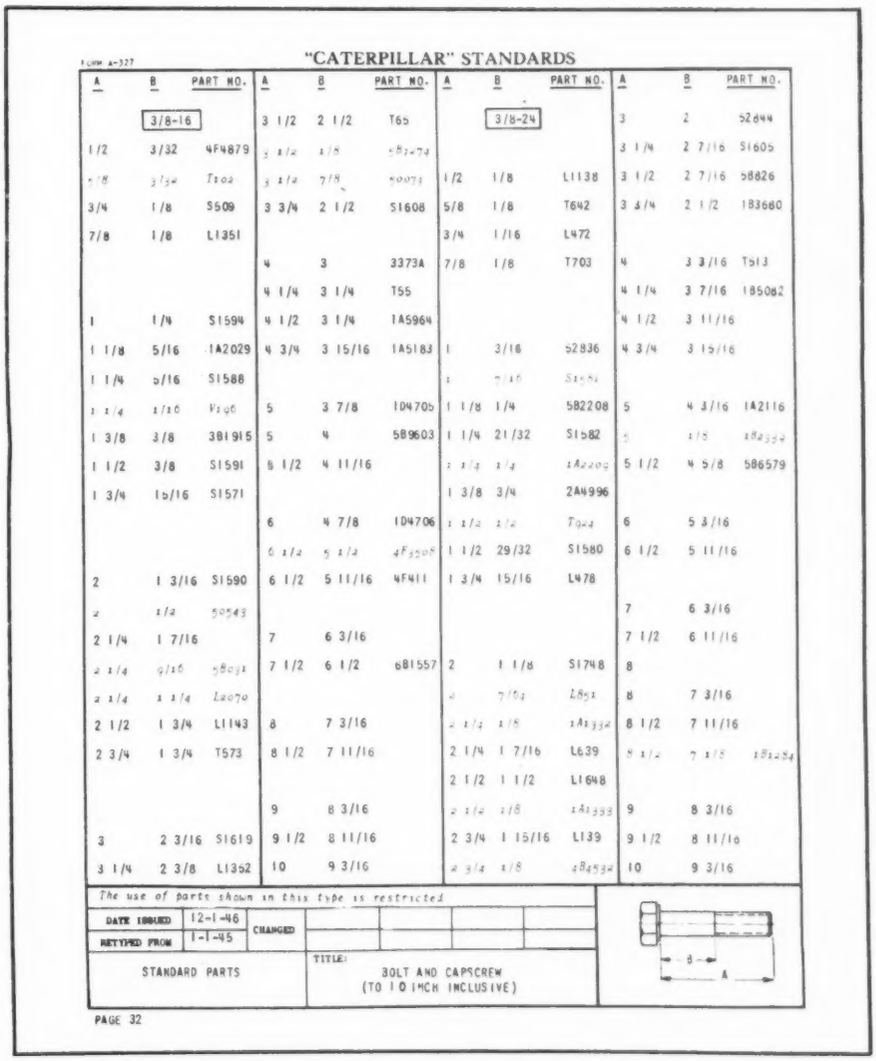
moval from the standard parts list entirely. If a check shows that a part is no longer used either for replacement purposes or for new design, it has no place in the standard parts volume and is taken out immediately. In this manner the book is kept up to date and is an effective working tool in the hands of those who use it.

Standards for Volume II and Volume III are prepared differently than the standards for Volume I. The point of origin for new or revised engineering or material and heat-treatment standards may be the engineering, metallurgical, manufacturing or research department. The need for engineering design standards and material and heat-treatment standards can be determined accurately by these departments rather than by the standards section. In general, when it becomes evident that a new design method or heat-treatment process has become established, so as to be generally recognized, a responsible person in the department affected is expected to suggest and discuss a new standard or a revised standard with the standards engineer. If the proposed standard appears to have some value, it is drafted by the standards engineer and submitted to the department that originated it for study, possible revision and approval. A proposed standard may be revised many times before final release. Following final approval

PART No._____ DATE_____
NAME_____ FOLLOW UP
PAGE No._____
MODEL No._____

CHECKER_____ STD. PARTS_____
SUPERVISOR_____ SIM. PARTS_____
FORM 7265

Fig. 1—A 3x5 in. offset printed form used to inform the standards division that the design of a part has been completed and is awaiting release to production.


"CATERPILLAR" STANDARDS

A	B	PART NO.	A	B	PART NO.	A	B	PART NO.	A	B	PART NO.
	3/8-16		3 1/2	2 1/2	T65		3/8-24		3	2	52644
1/2	3/32	4F4879	illegible	illegible	illegible				3 1/4	2 7/16	S1605
illegible	illegible	illegible	illegible	illegible	illegible	1/2	1/8	L1138	3 1/2	2 7/16	58826
3/4	1/8	S509	3 3/4	2 1/2	S1608	5/8	1/8	T642	3 3/4	2 1/2	183680
7/8	1/8	L1351				3/4	1/16	L472			
			4	3	3373A	7/8	1/8	T703	4	3 3/16	T513
			4 1/4	3 1/4	T55				4 1/4	3 7/16	185082
1	1/4	S1594	4 1/2	3 1/4	1A5964				4 1/2	3 11/16	
1 1/8	5/16	1A2029	4 3/4	3 15/16	1A5183	1	3/16	52836	4 3/4	3 15/16	
1 1/4	5/16	S1588				illegible	illegible	illegible			
illegible	illegible	illegible	5	3 7/8	104705	1 1/8	1/4	582208	5	4 3/16	1A2116
1 3/8	3/8	381915	5	4	589603	1 1/4	21/32	S1582	illegible	illegible	illegible
1 1/2	3/8	S1591	5 1/2	4 11/16		illegible	illegible	illegible	5 1/2	4 5/8	586579
1 3/4	15/16	S1571				1 3/8	3/4	2A4996			
			6	4 7/8	104706	illegible	illegible	illegible	6	5 3/16	
			illegible	illegible	illegible	1 1/2	29/32	S1580	6 1/2	5 11/16	
2	1 3/16	S1590	6 1/2	5 11/16	4F411	1 3/4	15/16	L478			
illegible	illegible	58543							7	6 3/16	
2 1/4	1 7/16		7	6 3/16					7 1/2	6 11/16	
illegible	illegible	illegible	7 1/2	6 1/2	681557	2	1 1/8	S1748	8		
illegible	illegible	illegible				illegible	illegible	illegible	8	7 3/16	
2 1/2	1 3/4	L1143	8	7 3/16		illegible	illegible	illegible	8 1/2	7 11/16	
2 3/4	1 3/4	T573	8 1/2	7 11/16		2 1/4	1 7/16	L639	illegible	illegible	illegible
						2 1/2	1 1/2	L1648			
			9	8 3/16		illegible	illegible	illegible	9	8 3/16	
3	2 3/16	S1619	9 1/2	8 11/16		2 3/4	1 15/16	L139	9 1/2	8 11/16	
3 1/4	2 3/8	L1352	10	9 3/16		illegible	illegible	illegible	10	9 3/16	

The use of parts shown in this type is restricted.

DATE ISSUED	12-1-46	CHANGED					
RETYPED FROM	1-1-45						
STANDARD PARTS		TITLE: BOLT AND CAPSCREW (TO 10 INCH INCLUSIVE)					

PAGE 32

Fig. 2—Typical page from Volume I, Standard Parts, indicating preferred parts.

of the standard, the standards section prepares the new standard for issue. In Fig. 3 are shown a number of typical standards pages.

The control of the contents of Volumes II and III is important. All information must be current and in usable shape. Employees, particularly new employees, are not likely to use information that is difficult to find, or information that they do not know exists. Consequently in making up the index, the objective is to list alphabetically every item in as many ways as possible. Tables I and II list the contents of both volumes.

One feature of Volume II is the design calculation sheets (see Fig. 4). These sheets are available from stock. Routine calculations are always made on standard calculation sheets. Constants and other standard data are stated on the sheets so that no reference materials are required. Filled in calculation sheets accompany a drawing for the checker's use. They are then forwarded to the standards section to be filed and cross-indexed. For example, gears are cross-indexed for part number, pitch and number of teeth. New gears having the same pitch and number of teeth as previously designed gears need not be recalculated, for the applicable data can be found in the files. Files of calculated data sometimes are the source of data for new standards.

The mechanics of issuing and maintaining standards volumes is well defined. Volume I is issued mainly to engineering, but other departments may also receive copies if they need them. Each copy is given a serial number, which appears on the form (Fig. 5) attached to the inside front cover of each book. Serial numbers begin with No. 1,001 and include both odd and even numbers. Volumes II and III are issued in pairs; the Engineering Standards bear odd serial numbers and the Material and Heat-Treatment Standards bear even serial numbers. Systematic issue simplifies the record and aids in keeping copies up to date. Volumes I and II find wide use and are distributed to many departments including engineering, metallurgy, research and production; every department has at least one pair for the benefit of those individuals who may occasionally have need for such information. A complete file of those to whom the standards have been issued is maintained by the standards section.

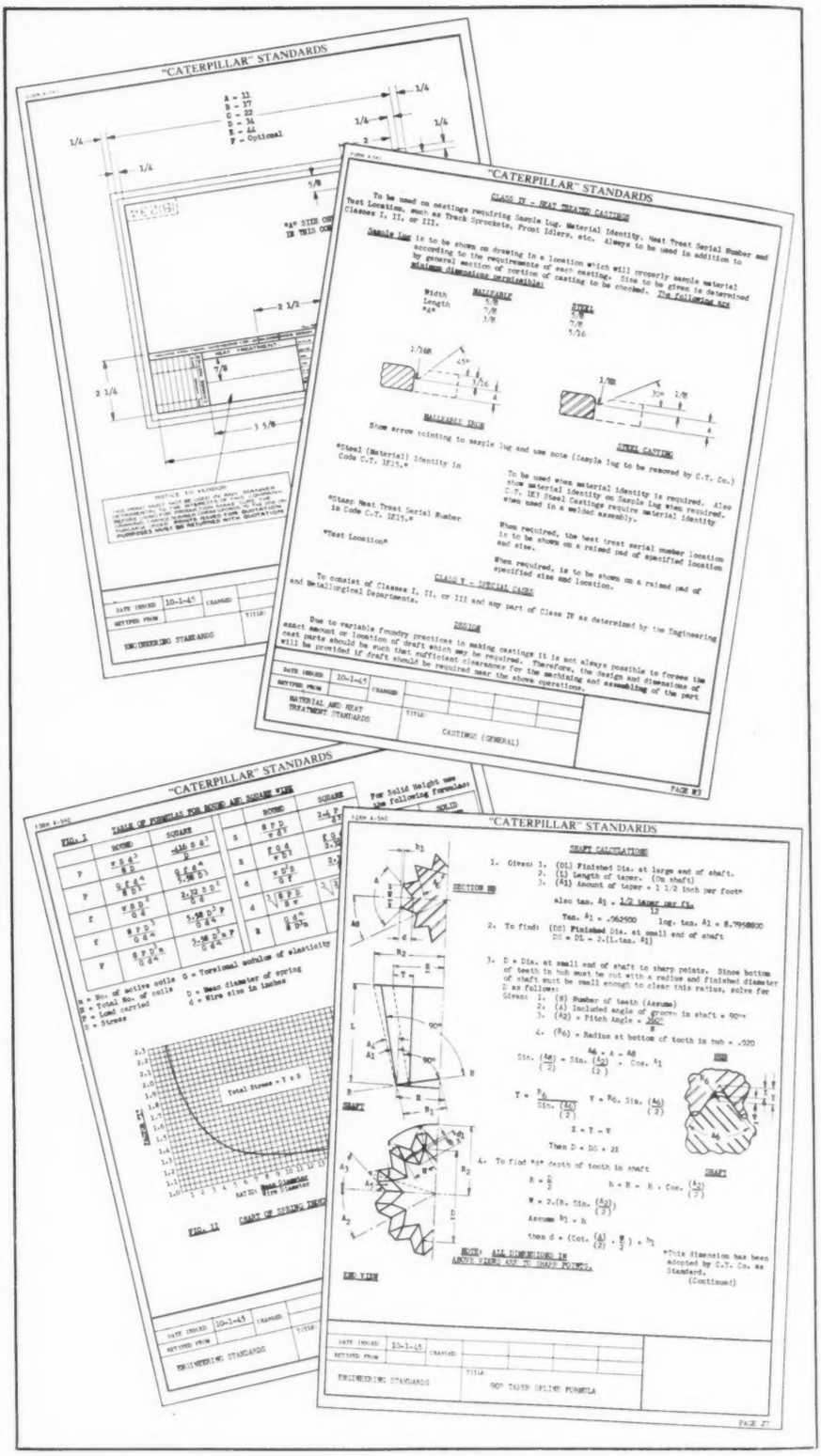
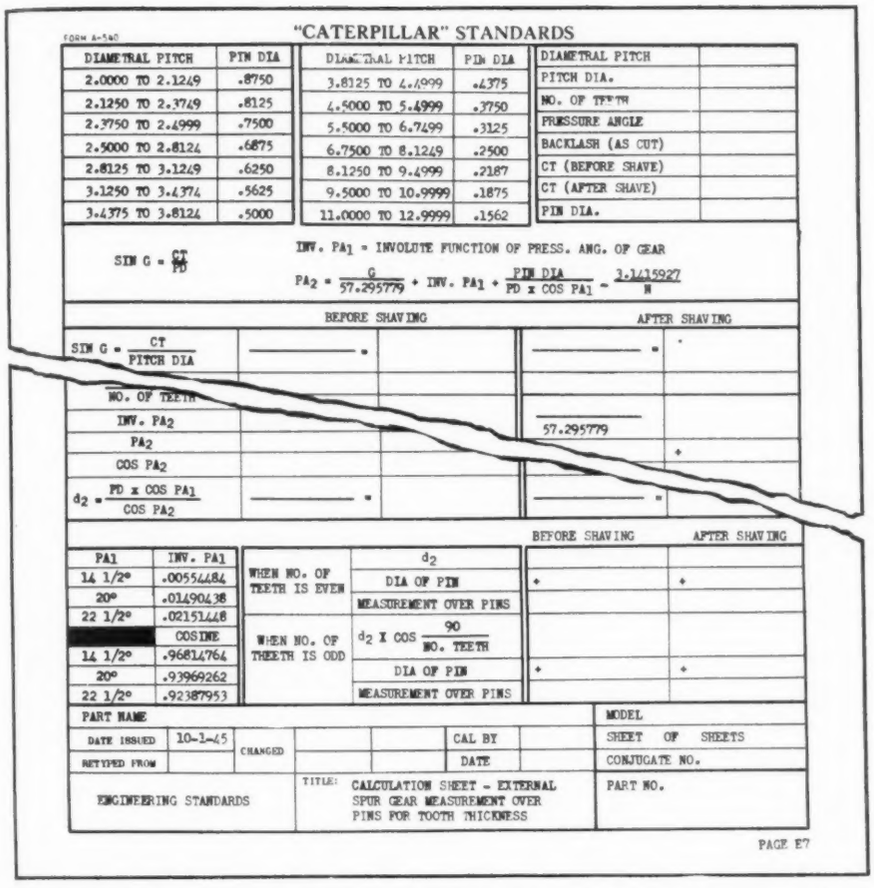


Fig. 3—Typical pages from Volumes II and III showing various types of standards.

New issues of standards are made as new standards are developed or old standards are revised. Standards appearing in Volume I are issued in batches, usually 10 offset printed sheets (20 pages) per change. Volume I is maintained by the standards section because this book is issued to departments or locations rather than to individuals. Volumes II and III are maintained by individuals. To make sure that these books are kept up to date, the standards section sends a form with each new release (Fig. 6).



"CATERPILLAR" STANDARDS

FORM A-540

DIAMETRAL PITCH	PIN DIA
2.0000 TO 2.1249	.8750
2.1250 TO 2.3749	.8125
2.3750 TO 2.4999	.7500
2.5000 TO 2.8124	.6875
2.8125 TO 3.1249	.6250
3.1250 TO 3.4374	.5625
3.4375 TO 3.8124	.5000

DIAMETRAL PITCH	PIN DIA
3.8125 TO 4.4999	.4375
4.5000 TO 5.4999	.3750
5.5000 TO 6.7499	.3125
6.7500 TO 8.1249	.2500
8.1250 TO 9.4999	.2187
9.5000 TO 10.9999	.1875
11.0000 TO 12.9999	.1562

DIAMETRAL PITCH	
PITCH DIA.	
NO. OF TEETH	
PRESSURE ANGLE	
BACKLASH (AS CUT)	
CT (BEFORE SHAVE)	
CT (AFTER SHAVE)	
PIN DIA.	

$\sin G = \frac{CT}{PD}$

INV. PA_1 = INVOLUTE FUNCTION OF PRESS. ANG. OF GEAR

$PA_2 = \frac{G}{57.295779} + \text{INV. } PA_1 + \frac{\text{PIN DIA}}{PD \times \cos PA_1} - \frac{3.1415927}{N}$

	BEFORE SHAVING	AFTER SHAVING
$\sin G = \frac{CT}{\text{PITCH DIA}}$	——— =	——— =
NO. OF TEETH		
INV. PA_2		——— 57.295779
PA_2		+
COS PA_2		
$d_2 = \frac{PD \times \cos PA_1}{\cos PA_2}$	——— =	——— =

PA_1	INV. PA_1
14 1/2°	.00554484
20°	.01490438
22 1/2°	.02151448
	COSINE
14 1/2°	.96814764
20°	.93969262
22 1/2°	.92387953

		BEFORE SHAVING	AFTER SHAVING
WHEN NO. OF TEETH IS EVEN	d_2		
	DIA OF PIN	+	+
	MEASUREMENT OVER PINS		
WHEN NO. OF TEETH IS ODD	$d_2 \times \cos \frac{90}{\text{NO. TEETH}}$		
	DIA OF PIN	+	+
	MEASUREMENT OVER PINS		

PART NAME					MODEL
DATE ISSUED	10-1-45	CHANGED		CAL BY	SHEET OF SHEETS
RETYPED FROM				DATE	CONJUGATE NO.
ENGINEERING STANDARDS		TITLE: CALCULATION SHEET - EXTERNAL SPUR GEAR MEASUREMENT OVER PINS FOR TOOTH THICKNESS			PART NO.

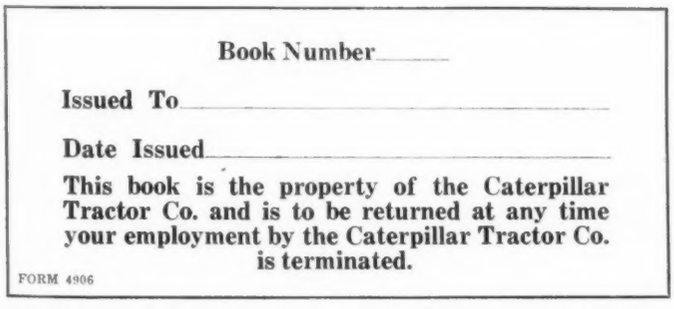
PAGE E7

Fig. 4—Design calculation sheets, such as this, are used for routine computations. Filled-in sheets are kept on file and are used for reference purposes. Sheets such as this reduce design time and encourage uniform design procedure.

This form, properly filled out and returned to the standards section, is evidence that the obsolete pages have been removed and the new standards have been inserted.

As a check for the standards section and to furnish a running record of the status of each standards volume, an additional form is used (Fig. 7). This form constitutes, in effect, the history of each volume. Through the proper use of the routine forms, the standards section can maintain a constant check on the location and status of all standards. In this way the standards section can be reasonably sure that all departments have available the latest standards information and that it is effectively discharging its function.

The standards system, although straightforward and logical, is, of course, subject to all the ills common to systems based upon routine paper work and related clerical activities. However, with reasonable attention paid to the selection of competent and adequate personnel to administer the system and with intelligent cooperation from all departments concerned, the savings realized are far greater than the cost of maintaining and administering the system.



Book Number_____

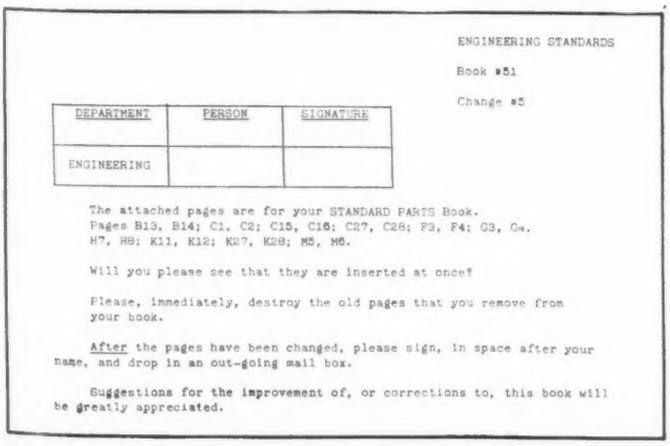
Issued To_____

Date Issued_____

This book is the property of the Caterpillar Tractor Co. and is to be returned at any time your employment by the Caterpillar Tractor Co. is terminated.

FORM 4906

Fig. 5—A legend sticker is placed on inside cover of each book.



ENGINEERING STANDARDS

Book #51

Change #5

DEPARTMENT	PERSON	SIGNATURE
ENGINEERING		

The attached pages are for your STANDARD PARTS Book.
Pages B13, B14; C1, C2; C15, C16; C27, C28; F3, F4; G3, G4, H7, H8; K11, K12; K27, K28; M5, M6.

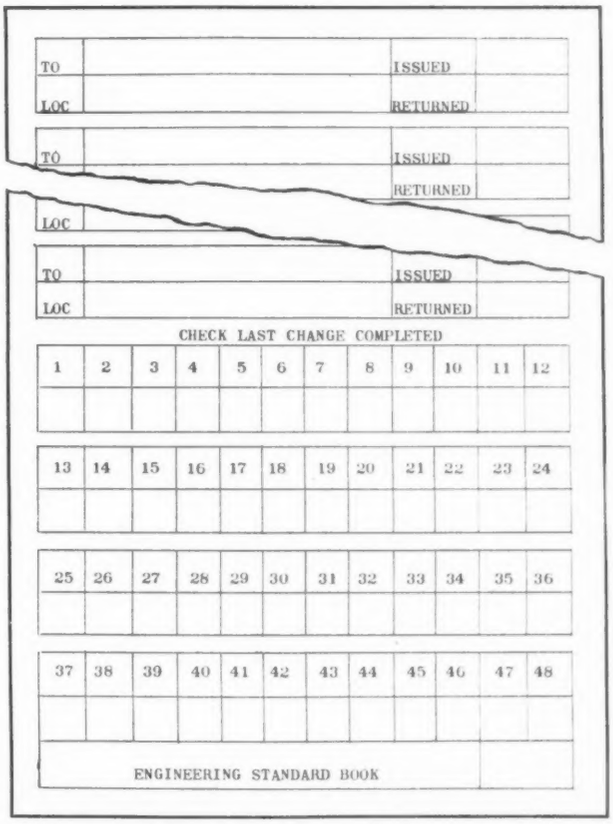
Will you please see that they are inserted at once?

Please, immediately, destroy the old pages that you remove from your book.

After the pages have been changed, please sign, in space after your name, and drop in an out-going mail box.

Suggestions for the improvement of, or corrections to, this book will be greatly appreciated.

Fig. 6—Typical receipt form for pages in Volumes II and III.



TO		ISSUED	
LOC		RETURNED	
TO		ISSUED	
LOC		RETURNED	
TO		ISSUED	
LOC		RETURNED	

CHECK LAST CHANGE COMPLETED

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48

ENGINEERING STANDARD BOOK

Fig. 7—Form for recording changes in Volumes II and III.

Fig. 1—Small zinc alloy die castings of many shapes and sizes compared with a die cast buckle of standard design.

Small Zinc Alloy Die Castings—

JOSEPH SAKS
Sales Manager, Gries Reproducer Corporation

Engineering design data for small zinc alloy die castings. Tables are given comparing the relative advantages of various production methods for small parts. Illustrations of parts economically produced as zinc alloy die castings are shown.

Maximum weight, oz	½
Maximum size in any one dimension, in	2
Minimum wall thickness, in	0.005
Tolerance per in. of diameter or length, in	0.001
Cast threads, maximum no. per in., external	40
Cored holes, minimum dia., in	0.015
Draft allowance per in., minimum on inside dimensions, in	0.003
Draft allowance per in., minimum on outside dimensions, in	0.005

Fig. 2—Engineering design data for specifying small zinc alloy die castings.

ZINC alloy die castings weighing less than ½ oz offer new design economies. Mass produced on automatic machines at rates as high as 100 pieces per min in a single cavity mold, they require few finish machining operations and permit flexibility in design.

A die casting weighing one ounce was once considered to be the minimum in size. Production problems encountered in the manufacture of the modern slide fastened by conventional machine processes led to the development of the die cast fastener. This fastener, shown in Fig. 4, has many small die cast elements. The slide and pull are also die castings although they are larger than the individual elements. To manufacture this product new production techniques were developed, which included redesigned die casting ma-

	Characteristics Compared	Small Zinc Alloy Die Casting Process	Brass Screw Mach.	Brass Stamping	Steel Screw Mach.	Steel Stamping	Molded Phenolic Plastics	Mall. Iron Casting	Bronze Casting	Cold Forging and Swaging
Relative cost factors	Production Speed	2	3	1	4	1	5	8	7	6
	Tool Cost	3	1	5	1	5	4	2	2	5
	Cost of applied finish	4	3	2	3	2	.....	6	5	3
	Cost of Matls. per Lb.	2	4	4	1	1	5	1	2	*
	Scrap Lost (Cost)	1	6	5	4	3	2	3	2	*
	Overall Production	2	3	1	4	1	5	7	6	5
Relative design features	Flexibility of Design	1	5	4	5	4	2	3	3	4
	Feasibility of Designing Part as 1-piece Unit	1	4	3	4	3	2	1	1	2
	Feasibility of Producing Complete Part in 1 Primary Operation	1	2	1	2	1	1	5	4	3
	Minimum Size of 1 Piece	1	3	2	3	2	3	4	4	3
	Maximum size of 1 Piece	5	3	2	3	2	2	1	1	4
	Ease of Holding Close Dimensions	1	1	2	1	2	3	6	5	4
	Machining Cost After Casting	1	1	1	1	1	1	4	3	2
	Accuracy in Cored Hole Size and Location	1	.....	.....	.....	.....	2	3	3	.....
	Surface finish without special finishing operations	3	2	2	2	2	2	6	5	4
	Ease of Attaining good finish	2	3	2	3	2	1	5	4	3
	Feasibility of Producing parts with thin sections	2	2	1	2	1	3	5	5	4
	Degree of Uniformity Attainable	1	4	2	4	2	3	6	6	5
	Weight per Piece of Same Size	2	6	6	4	4	1	3	5	*
	Weight per piece of equal strength	5	3	2	2	1	4	5	6	*
	Tensile strength of matl.	6	4	3	1	2	8	5	7	*
	Relative impact strength	4	2	2	1	1	6	3	5	*
Average physical properties	Ult. Tensile strength, psi	42,000	60,000	70,000	87,000	72,000	6,500	54,000	35,000	*
	Elong. in 2 inches, %	4.5	30	45	17	24	0.6	18	25	*
	Hardness, BHN	68	45	47	183	123	38	115	55	*
	Specific gravity	6.7	8.4	8.4	7.8	7.8	1.4	7.3	8	*

*Depending upon material.

Fig. 3—Chart showing comparisons of cost, design features and physical characteristics of various production methods.

Economic and Design Advantages

chines and unconventional casting dies. The successful production of the slide fastener proved that such small die castings can be produced economically.

This process is now applied to the manufacture of many other small parts. No manual handling of the pieces is required. The finished part is made in one operation and, as in all die castings, the raw material is used in ingot form without waste.

A chart showing the comparison of production cost, design features and physical properties of zinc alloy die castings with stampings, screw machine parts and castings is shown in Fig. 3. A rating of "1" indicates the most favorable condition. Specific cases such as unusually high or low production rates, limitations of existing equipment and adaptability may alter the relative position of some of these items. Usually a zinc alloy die casting can economically replace a brass screw machine part if the brass part has 50 percent or more scrap loss.

Design data for small die castings are given in Fig. 2. Two commercial alloys are used for zinc die castings. The standard alloy consists of zinc, 4 percent aluminum plus magnesium. The second alloy, used when operations after die casting require added ductility, consists of zinc, 4 percent aluminum, magnesium and 1 percent copper. Many types of finishes such as zinc, nickel, brass, chromium, silver, gilt, paint or chemical black can be specified to suit the requirements of the design.

When redesigning small pieces for manufacture by zinc die casting, the designer usually has to make only

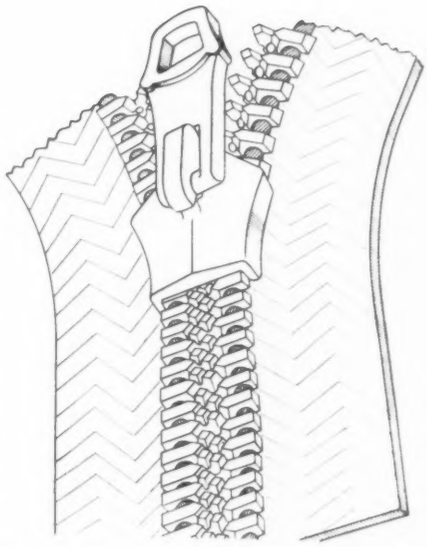


Fig. 4—The first small zinc alloy die casting design: the ordinary slide fastener. All individual components are die castings.

Fig. 5—Die castings that are usually manufactured by sand casting, forming and brazing production methods.

Fig. 6—Formerly made by cold forging operations these parts are economically made as zinc alloy castings.

minor changes in the specifications if the parts had been designed to be produced by operations such as sand casting, wire forming and cold forging. Often the appearance and utility of the product can be improved because there are few shape limitations in die cast parts. There are some parts in which the designer is often hampered by the inability to produce them by any other process because of smallness, lack of tool clearance or labor cost. By specifying zinc alloy die castings many of these limitations can be avoided.

Typical examples of die cast zinc alloy parts formerly produced by sand casting, wire forming and brazing methods are shown in Fig. 5. The belt buckle has an imitation roller, die cast on the body. The tongue is an individual die casting and is assembled to the buckle by a crimping operation. The cup hook is another interesting example of cost reduction achieved by die casting as one piece. These hooks are usually made as a wire forming, which is machine threaded. A stamped flange is then assembled to the hook. As a die casting the hook is made in one piece and is merely tumbled and plated after casting.

Die cast parts that are usually produced by cold forging operations are shown in Fig. 6. The standard wing nut shown requires only a tapping operation after casting. The wings are recessed to reduce weight and provide a firm finger grip. A smooth faced extended boss is provided at the base of the nut. This is an example of a part that has had its general appearance improved by being made as a die casting.

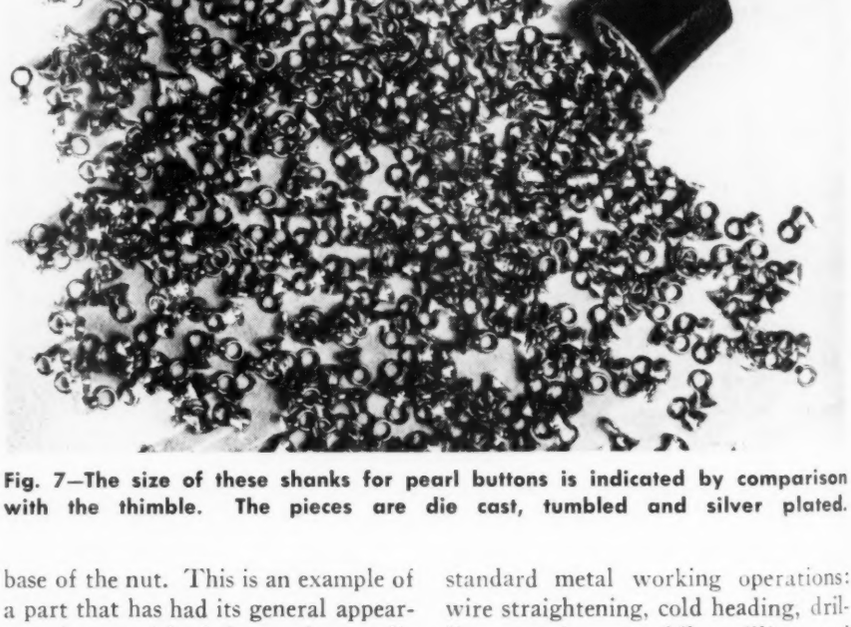


Fig. 7—The size of these shanks for pearl buttons is indicated by comparison with the thimble. The pieces are die cast, tumbled and silver plated.

The special wing nut illustrated in Fig. 6 has a recess that is cast in the body to receive a special non-metallic washer. The washer is peened into the recess. A counterboring operation was eliminated by the use of a zinc die casting. The purse knob is an example of a part that was die cast after failure to produce the part economically from wire by cold forging.

Parts made into die castings by merely changing the material specifications are shown in Fig. 8. The bicycle wheel spoke nipple made as a wire forming required the following standard metal working operations: wire straightening, cold heading, drilling, tapping, straddle milling and slotting. As a die casting it is cast in one operation and requires only a tapping operation to finish it. The thumb tack is usually made as a stamping or as a stamping and wire forming assembly. The entire thumb tack is cast in one piece when made as a die casting.

The hollow end rivets shown in Fig. 8 are also cast in one piece. Many other shapes of rivets having square shanks, square holes and external or internal integral keys can be cast in zinc alloy. The rivet is an example of a part made from a ductile zinc alloy, which can be bent easily.

Fig. 8—Parts that were designed as die castings by changing only the blueprint material specifications.

Fig. 9—Made by any other method than die casting these parts would be expensive and difficult to manufacture.

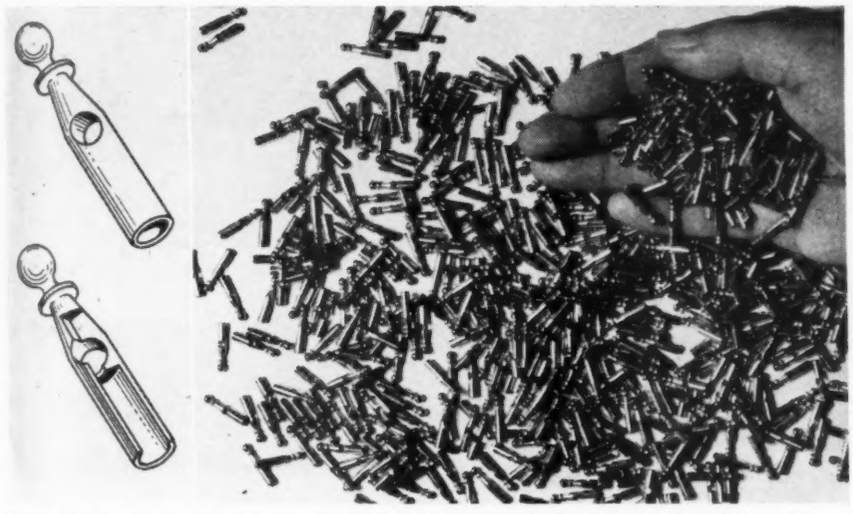


Fig. 10—A few minutes production of die cast umbrella tips. Cast at a rate of 100 pieces per minute they have a 0.040 in. cored hole to facilitate plating.

The smallest rivet shown is only $\frac{1}{32}$ in. dia by $\frac{1}{32}$ in. long.

The laundry collar button shown in Fig. 8 is an interesting illustration of competitive price differential. This part was formerly made of wood and yet as a die casting it competes economically with the original product. The product as a die casting has better uniformity, more strength and a better appearance than a wood turning.

Die cast parts with shapes that are difficult to produce by ordinary machine operations are shown in Fig. 9. The size of these parts is indicated by the small ring in the illustration. This ring weighs less than 3½ milligrams and has a $\frac{3}{16}$ in. outside diameter. As die castings these rings are produced in quantities of millions without any scrap loss. There is no other economical method of making them. The knurled shape on the outside of the screw post nut is die cast in the part. Often decorative shapes such as the threaded clock weight are desired. Since this weight has individual threaded grooves on a curved surface, it is not practical to make it on a screw machine. The die cast piece is easily produced.

The button shanks shown in Fig. 7 being poured out of an orginary thimble, represent a type of small pieces that were not produced domestically because of economic reasons. They were made of a soldered assembly of a hollow, thin walled, bell-shaped stamping and a wire formed eye. Only relatively low paid foreign workers could produce them economically. Since they have been made as die castings they are no longer imported. The wall of the bell section is 0.006 in. thick. Eyes are cast with either round or square holes. The parts are silver plated after tumbling.

An interesting example of a part in which production was facilitated by die casting is shown in Fig. 10. These umbrella rib tips weigh only 0.0017 lb and are produced as zinc die castings at the rate of 100 pieces per minute in a single cavity mold. No hand work of any kind is used in their production. They are cast, tumbled and plated to a specified finish. The hollow cored section is ¼ in. deep by 0.108 in. dia and has a wall thickness of only 0.018 in. The sewing hole is 0.078 in. dia and is produced free of sharp edges or obstructions. A vent of 0.040 in. dia connects the cored hole and sewing hole. This vent prevents trapping of air and thus provides drainage for the plating solution.

The economic advantage of designing small die cast parts should not be overlooked by the designer. Often the success of a new design hinges upon the operation of a tiny obscure part that is difficult to produce within the specified tolerances by standard operations. By designing these components as zinc alloy die castings many problems can often be avoided.

P R O D U C T

BODY on the 1948 Packard Convertible has front fender lines extended through one-piece doors to meet rear fenders.

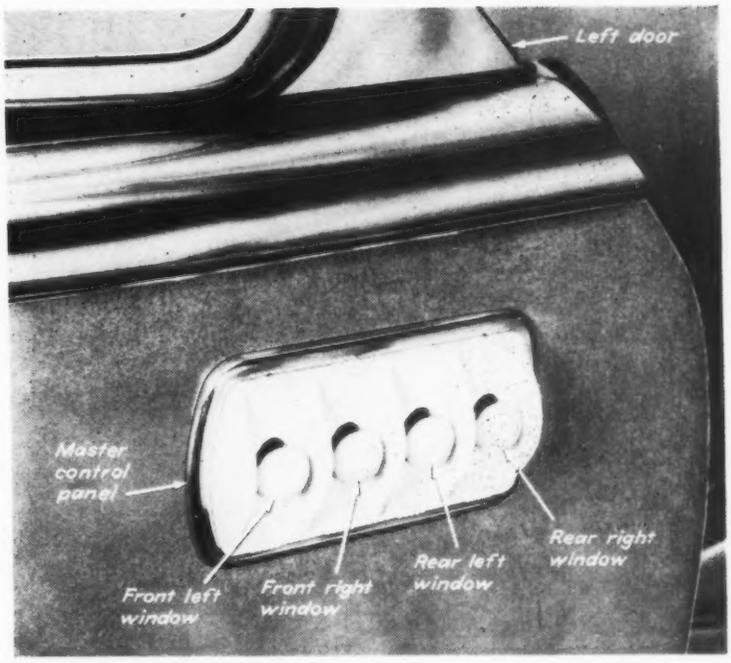
2 FRONT SEAT adjustment is also hydraulically operated by a push button control. Front seat backs are pivoted so that they tip forward and away from the doors, giving room for back seat entrance. Floor is welded steel.

3 ALL INSTRUMENTS on the instrument panel are located in front of the driver. Light reflection from the panel at night is reduced by using filters on panel lights in conjunction with fluorescent painted numerals and pointers on the dials. Radio mounts in the center of the panel. The functions of the various switches are die cast in the control knobs. Circuit breakers are used throughout the electrical system except for fuses in the circuits of the radio and heater. Instrument vision is improved by two spoke steering wheel.

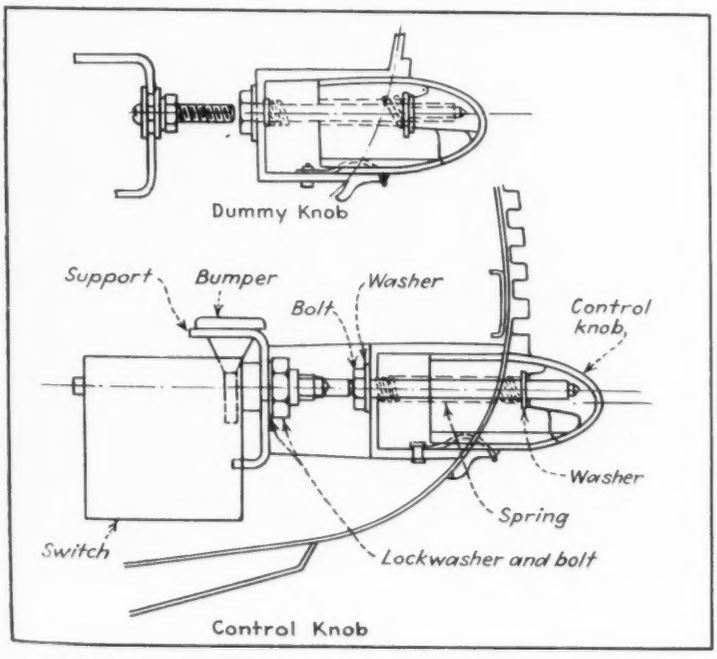
D E S I G N S

Body Styling And Engine Design Details of the 1948 Packard

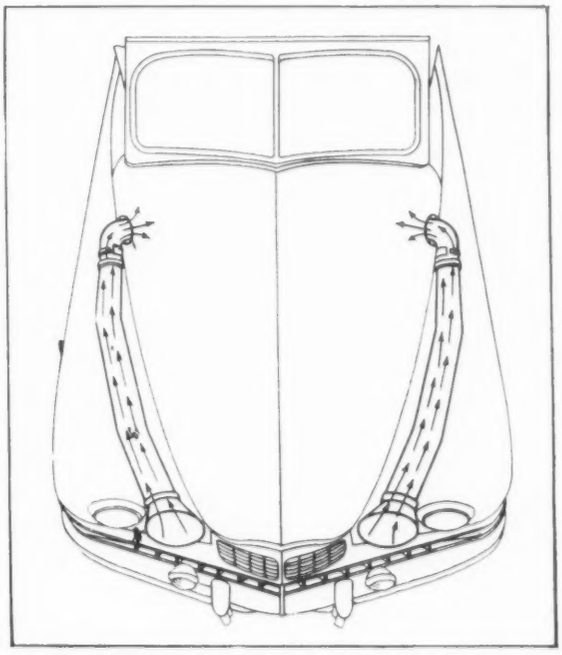
Body styling, new 145 hp engine and many improvements in overall design feature the 1948 Packard Convertible. The car has a wheelbase of 120 in. and an overall length of 205 inches. Windows, top and front seat adjustment are hydraulically operated. A twin duct ventilating system has individual controls for regulating the flow of fresh air to the front seat compartment.



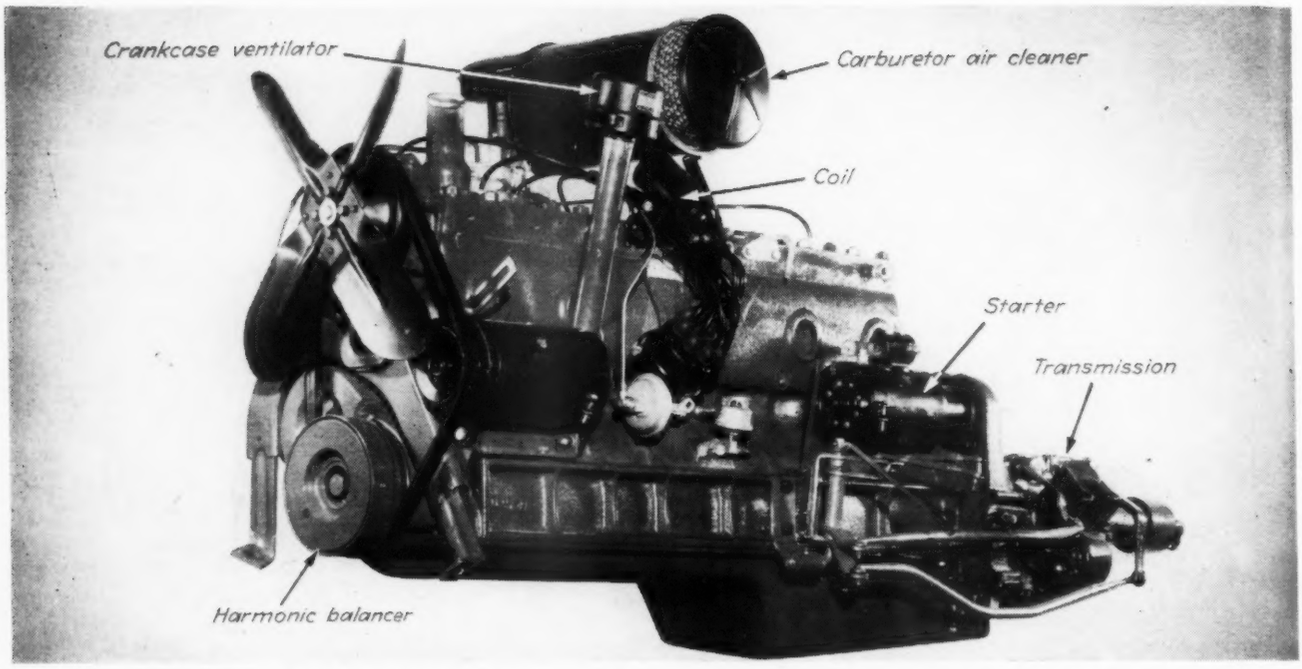
1 **ALL WINDOWS** are hydraulically operated by pushbutton controls. Controls are individually placed for each passenger. A master control panel is located beside the driver on the left hand door. Upholstery is vinyl plastic and bedford cord construction. The plastic material is used for the interior finish on the double panelled doors. Safety glass windows are outlined with chromium trim. Top is raised and lowered hydraulically.



4 **CONTROL KNOBS** that operate the switches for the lights and accessories stay in trim alignment whether in "on" or "off" position. Switches are mounted on a bracket behind the die cast instrument panel. The control keys operate the switch through a bolt threaded into the knob. After the switch has been operated, a spring returns the knob to its original position. Dummy knobs are mounted in spaces where no switch is required.



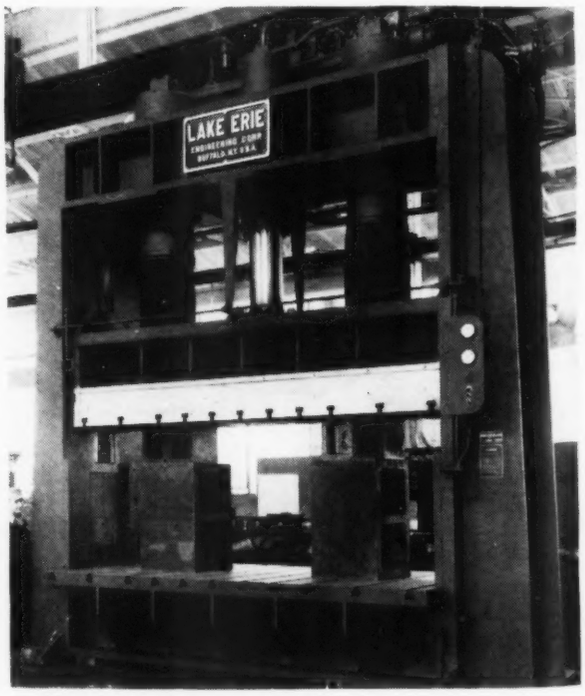
5 **FRESH AIR VENTILATION** is provided by two welded sheet metal 5 in. dia. ducts. Air enters ducts through the grill and is forced through screened openings at each side of the driver's compartment under the instrument panel. Each duct has individual control knobs on the panel for regulating the amount of fresh air.



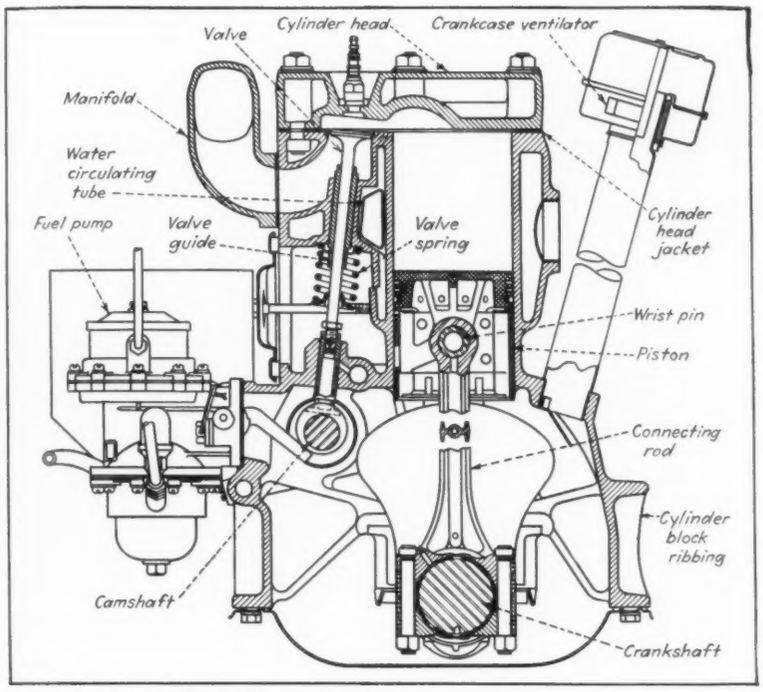
6 EIGHT CYLINDER ENGINE has a compression ratio of 7.0 to 1. Former engine had 6.85 to 1 ratio. Cylinder block has been strengthened by rib section additions that were determined from stresscoat analysis. Redesigned manifold gives better fuel distribution by being level when engine is mounted in car. Water pump shaft has been shortened to decrease deflection and reduce wear. Valve diameters have been increased and induction hardned camshaft redesigned. Valve guides are manganese phosphate coated to eliminate former finishing operation after assembly. Cast iron camshaft sprocket is hardened to reduce wear. Coil has been moved from heat wall and is now mounted on engine. Steering gear ratio has been changed from 20.4 to 26.2 to 1, for easier steering.

Welded Construction For Light Tonnage Hydraulic Forming Press

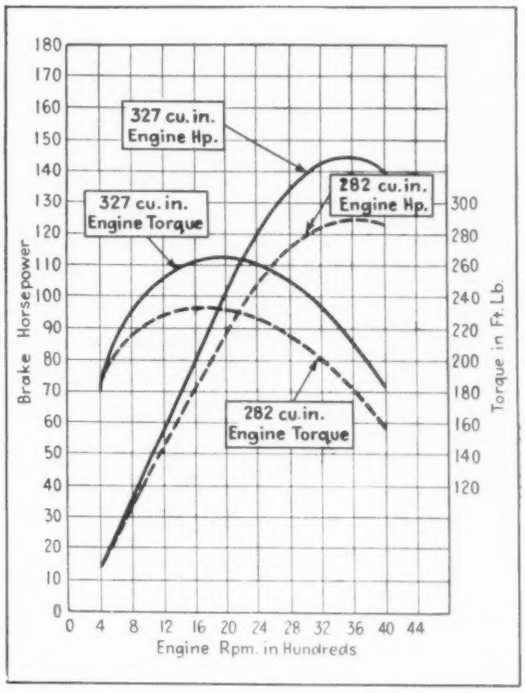
Designed for light tonnage with a comparatively large bed area, the 500 ton self contained downstroke hydraulic press made by the Lake Erie Engineering Co., Buffalo has a welded frame construction. The side frames consist of a heavy plate with stiffening ribs. Similar construction is used for the top and bottom platens, which are keyed and bolted to the side members. The top platen supports the forged steel hydraulic cylinders and the pumping unit. The moving platen is fastened to the center ram by a flange and to the side rams by split collars. It is guided by the center ram and has cast iron gibs that bear on guides fastened to the side frames. Stop plates on the side frames limit the stroke.



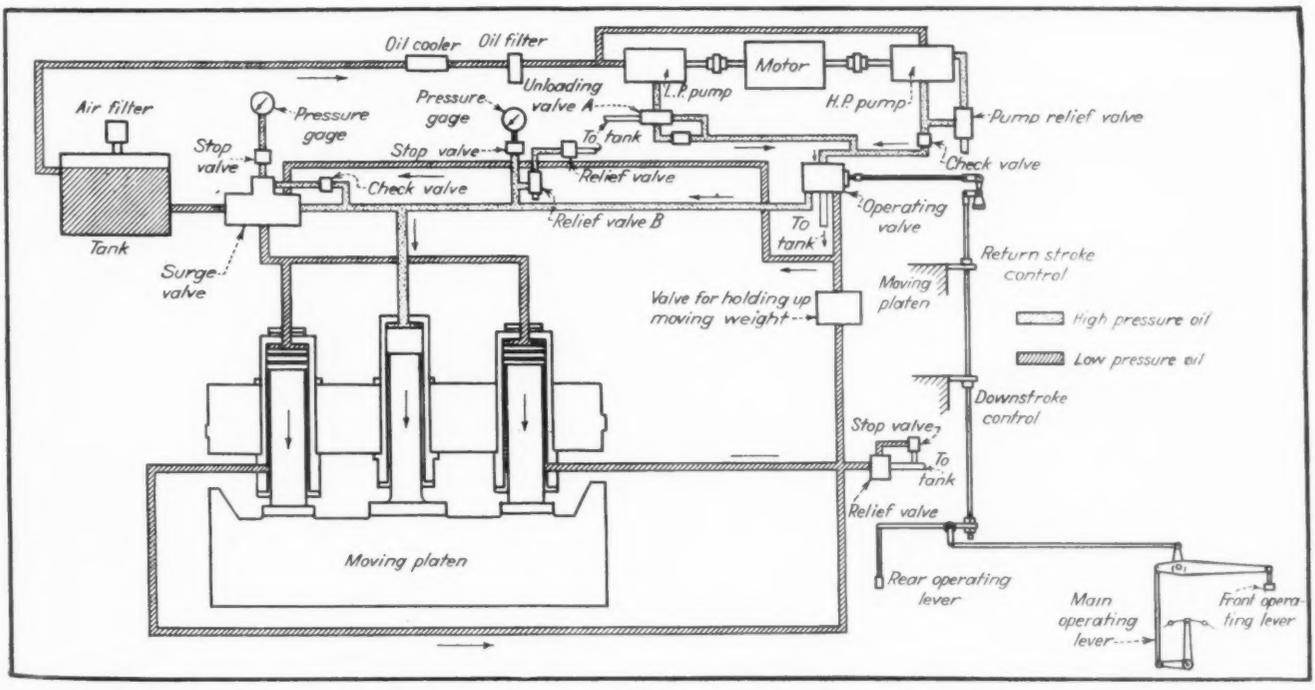
1 THE PRESS is set so that the top of the bottom platen is flush with the floor. An operating panel includes pressure gages for all ram pressures, a remote control relief valve and the pump motor control switches. The main oil tank is located at the top rear of the press. It is supported by brackets that are fastened to the top platen.



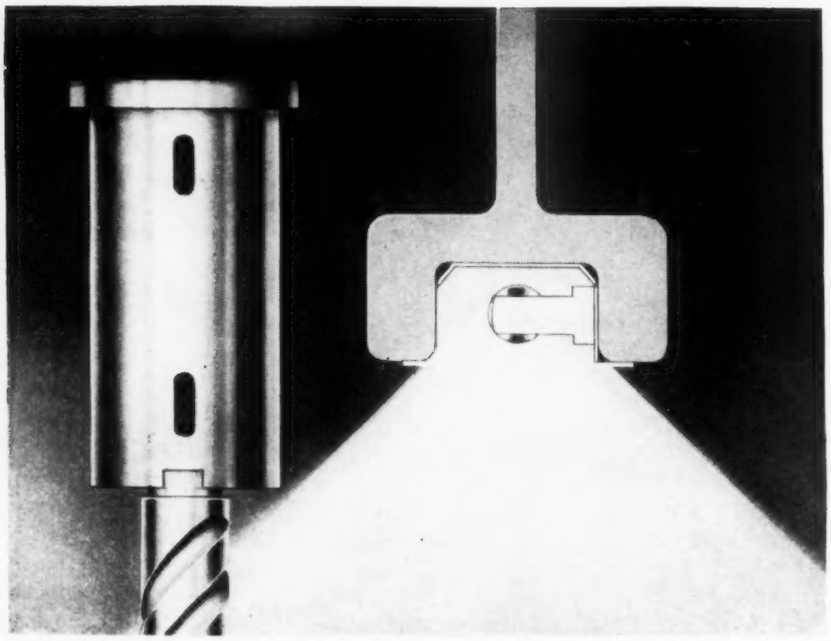
7 **VERTICAL SECTION** through engine shows moving components. Engine is an L-head type with cylinders cast en bloc. Gasket area between cylinder and block has been increased. Water circulation has been improved by increased size of brass circulating tube section. Crankshaft rod bearing diameter has been increased from 2 3/32 in. to 2¼ in. to reduce loading. Main and connecting rod bearings are a copper nickel matrix with impregnated lead base babbit.


327 cu. in. Engine Hp.
327 cu. in. Engine Torque
282 cu. in. Engine Hp.
282 cu. in. Engine Torque
Brake Horsepower
Torque in Ft. Lb.
Engine Rpm. in Hundreds

8 **NEW ENGINE** has 327 cu in. displacement and develops 145 hp at 3,600 rpm. Maximum torque is 266 ft lb at 2,000 rpm. Former engine has 282 cu in. displacement. It developed 125 hp at 3,600 rpm. Maximum torque was 234 ft lb at 1,750 rpm. Axle ratio was changed from 4.1 to 1, to 3.9 to 1 for new engine.



2 **HYDRAULIC CIRCUIT** includes a motor, two pumps and three cylinders that contain the press operating rams. When the operating valve is closed, both the high and low pressure pumps deliver oil to the center cylinder and move the platen down at high speed. Side cylinders are pre-filled during the stroke through the surge valve. When the moving platen contacts the work, center ram pressure builds up, closes the surge valve and admits oil from the pump to the side cylinders. When pressure in the cylinders builds up to the setting of unloading valve A, the low pressure pump is by-passed into the tank. Operating pressure of the cylinders is determined by setting of valve B. When operating valve is shifted to return position, pumps are connected to the bottom of side cylinders.

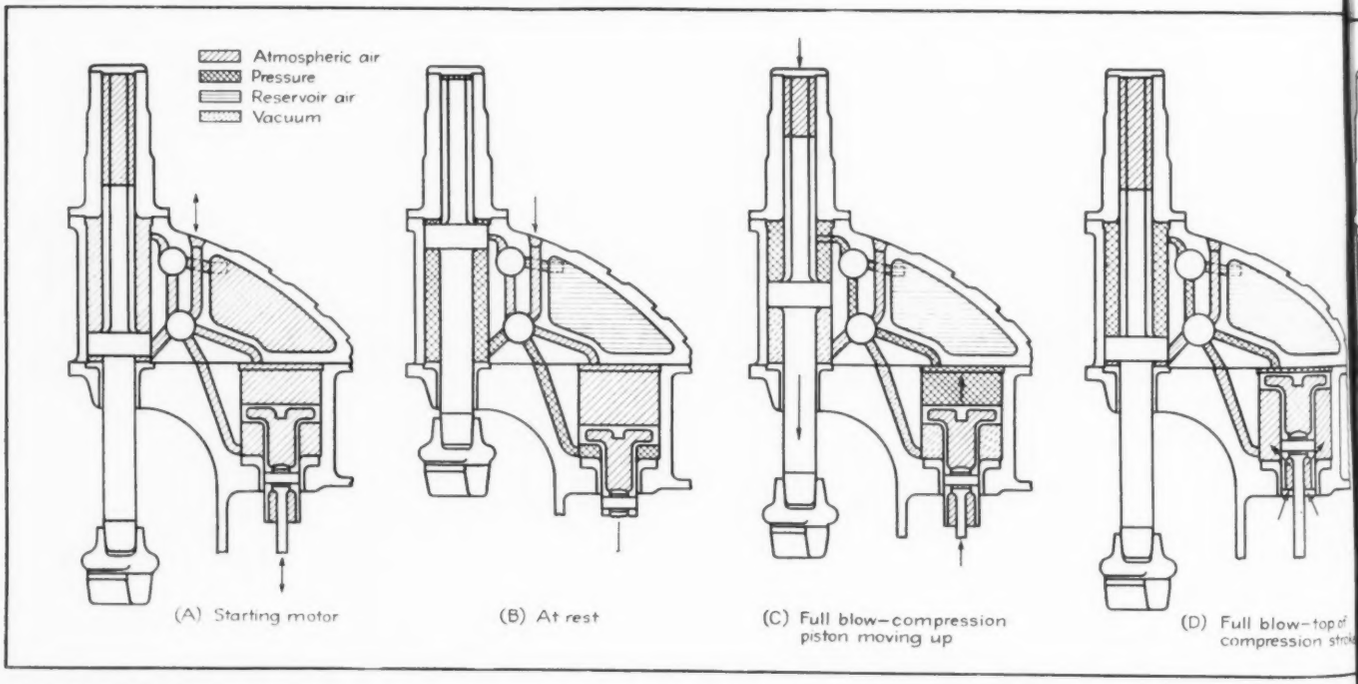


Neon Tube Is Recessed in Casting

ALL RADIAL DRILLS manufactured by the Fosdick Machine Tool Co., Cincinnati, Ohio, have a new type of electric light for illuminating the spindle and work. The bottom of the arm is cast with a recess into which a neon tube is inserted. On 6 ft machine, a tube 4 ft long is used. By this type of design, illumination is provided for any position of the head on the arm. The tube is easily removed for replacement and is not in danger of being broken during setup or drilling operations. Because no adjustment is necessary, operation setup time is reduced.

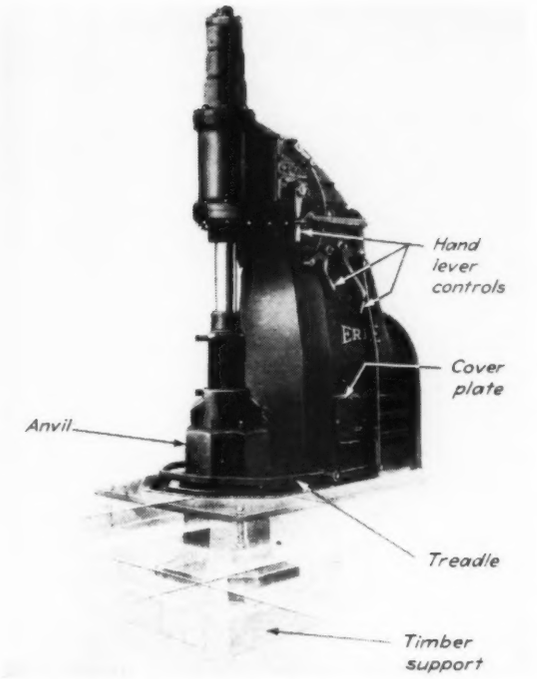
Pneumatic Hammer Has Rotary Valve Controls

By changing the position of rotary valves, an operator can strike a single blow, strike a fixed number of blows per minute or clamp work between the dies on the pneumatic hammer made by Erie Foundry Co., Erie, Pa.

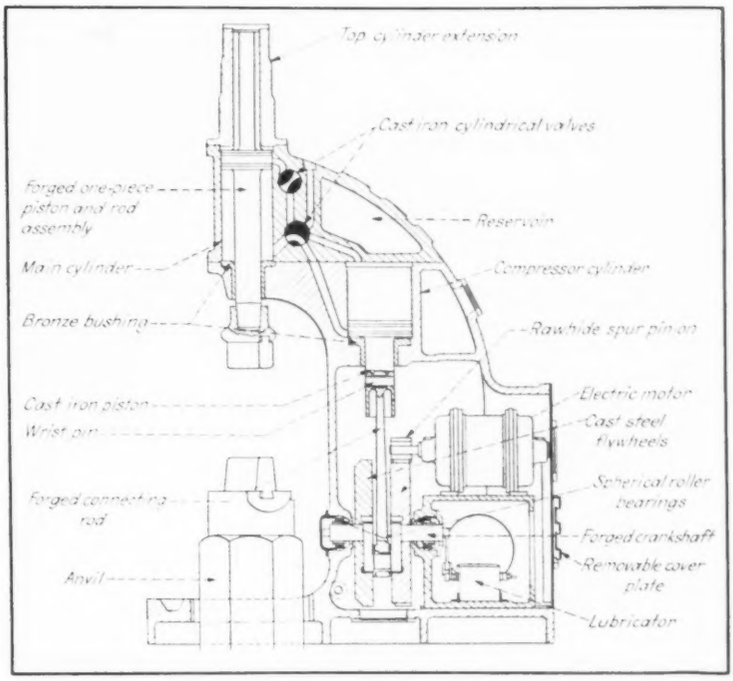


3 STARTING CONDITIONS are shown in A where an unloading valve is used. When the starting valve is turned to the running position, the ram rises to the "at rest" position shown in B. When the pressure in the reservoir reaches a predetermined maximum, the compressor does no work until a blow is struck. Diagrams C, D, E and F illustrate the conditions while a full blow is struck. The ram and compressor cylinders are connected together so that the two pistons move in opposite directions as shown by the arrows. Compressor pressure is equalized as shown by the arrows in D and F. On the upstroke, the ram is cushioned by the air trapped above the piston rod. Blows of lesser force are struck in a cycle between the extremes shown by B and C, D, E and F. The pressures

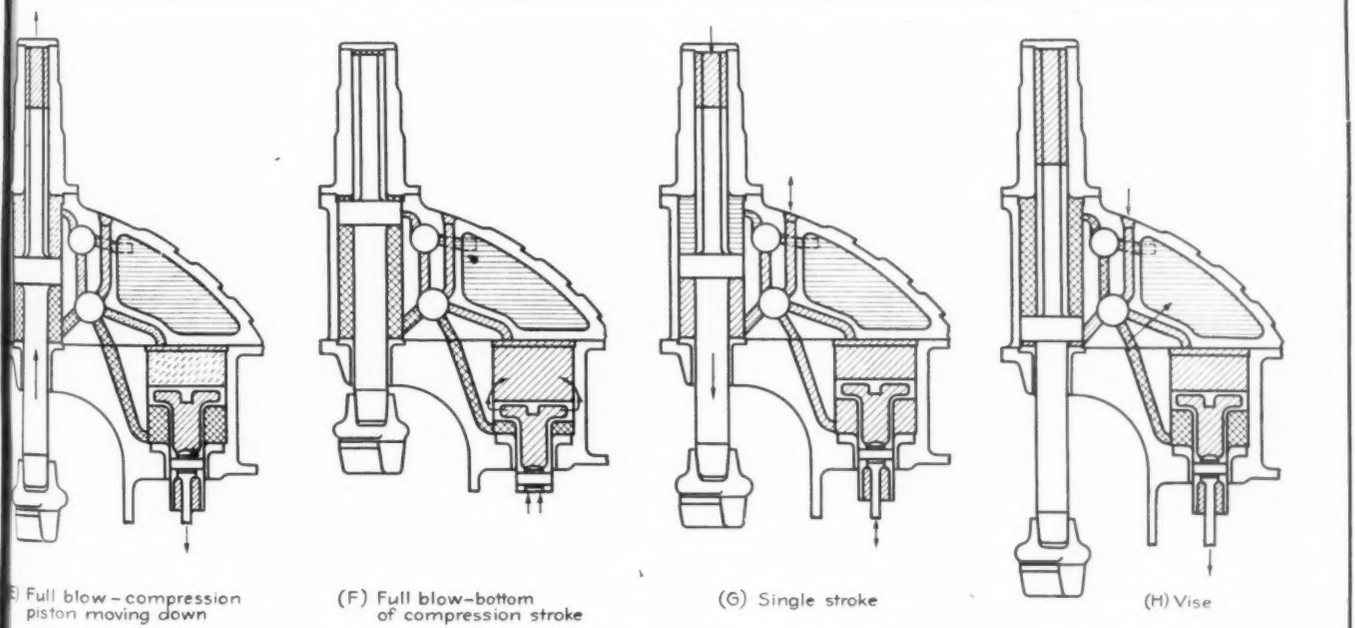
D E S I G N S



1 VALVES are operated by treadle or hand controls. The anvil of the hammer is separate from the frame of the machine and is supported by a timber cushion under the frame. The octagonal shape of the anvil permits die faces to be placed in four different positions 45 deg apart. All compressor parts are inclosed in the frame.



2 GUIDES at the top and bottom of the main cylinder maintain piston rod alignment and reduce cylinder bore wear. Unit pressure on the guides is lowered by making the length of the guiding surfaces twice the stroke of the hammer when the dies are closed. Hardened steel inserts that bear on the upper piston rod extension prevent rotation of the piston and resist wear. Leakage between guiding surfaces does not affect hammer operation.



(E) Full blow – compression piston moving down

(F) Full blow – bottom of compression stroke

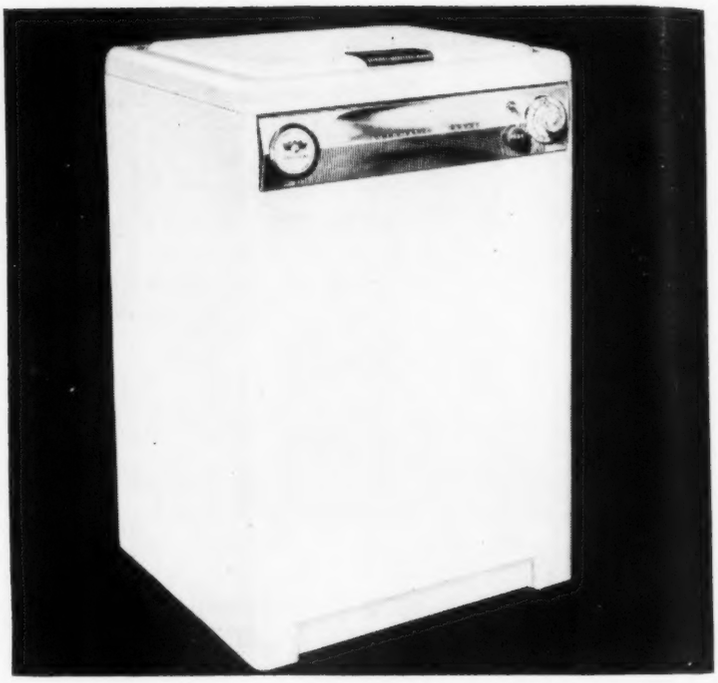
(G) Single stroke

(H) Vise

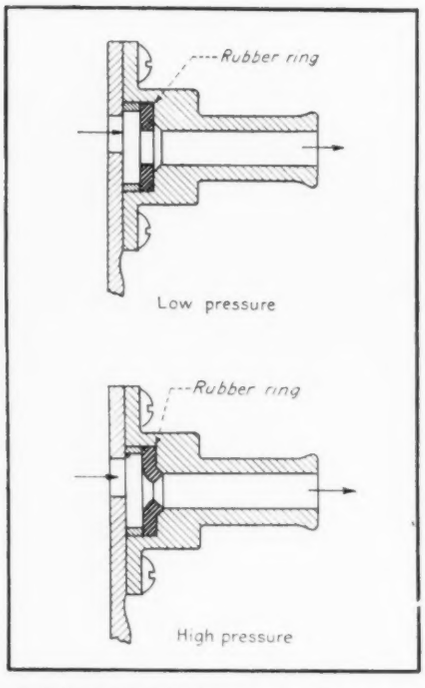
at this time are less and the vacuum is lower than when striking a full blow. The exhaust opening is in a middle position between open and closed, depending upon the force of blow desired. The operation used when striking a single blow is shown in G. The top and bottom of the compressor are connected to the exhaust. The reservoir is connected to the top of the ram while the bottom is also exhausting. The force of this blow can be controlled by varying the opening in the valve. Conditions for the clamping operation are shown in H. The connections between the compressor and the ram are reversed so that the bottom of the compressor is connected to the top of the ram. The top of the compressor and the bottom of the ram are connected to give atmospheric pressure.

Pulsating Action For Automatic Washer

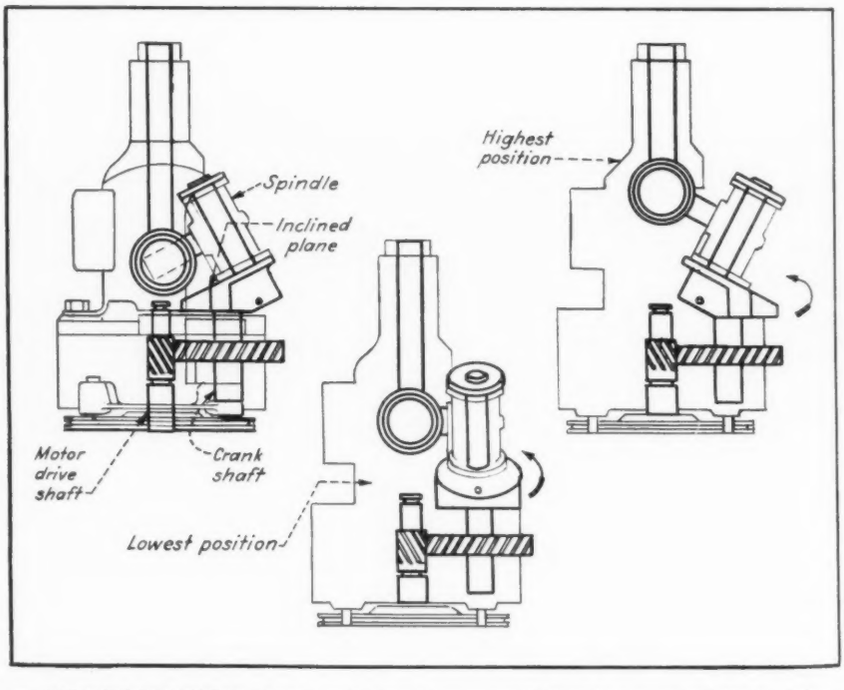
A conical-shaped vertical plunger that reciprocates five times per second gives a pulsating action to the water in Frigidaire's new automatic home washer. The rotating parts are dynamically balanced so that the machine does not have to be bolted to the floor. One setting of the single control dial determines the automatic action that takes less than 30 min: washing, two rinsings, spinning to damp-dry and cleaning the machine. If the lid is lifted during operation, the motor stops. Spinning action also stops if clothes bunch in the tubs.



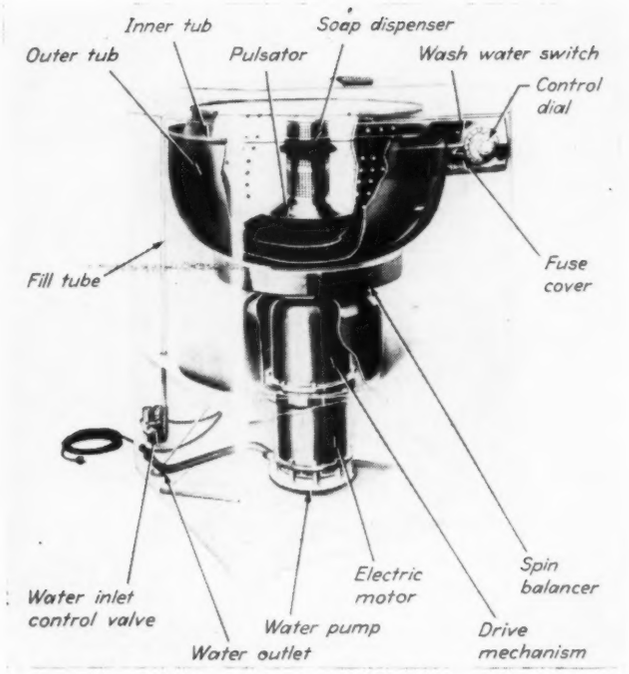
1 **WASHER** is top loading, and when closed the top can be used as a work surface. The cabinet is electrically welded from sheet steel. It is finished in porcelain as are both tubs. Adjustable legs are provided for levelling the machine on uneven floors. soap is placed in a distributor and released gradually as suds, thus avoiding clothes stain. Water is metered into the tubs at the rate of 4 gpm regardless of the line water pressure available.



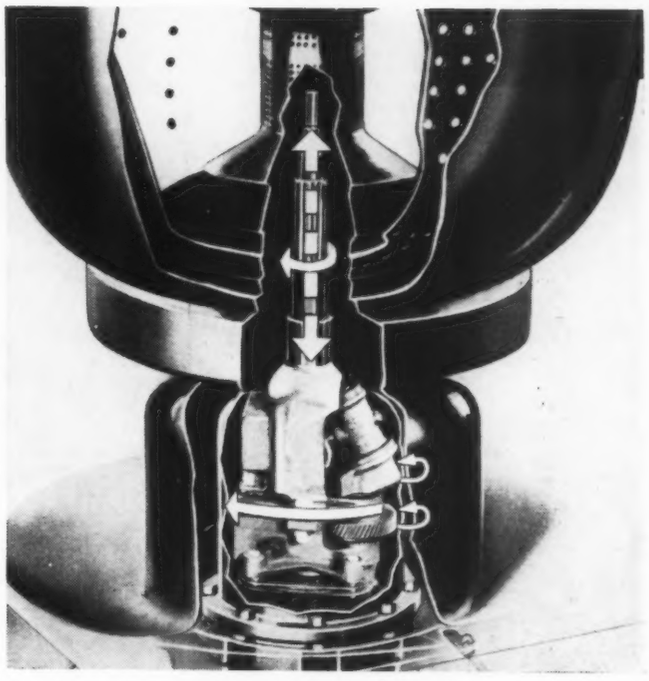
4 **RUBBER RING** controls the rate of water flow to the tubs. At low water pressures of approximately 25 psi, the opening in the ring will pass 4 gpm. As the water pressure increases, the ring bends outward and the smaller opening restricts the flow.



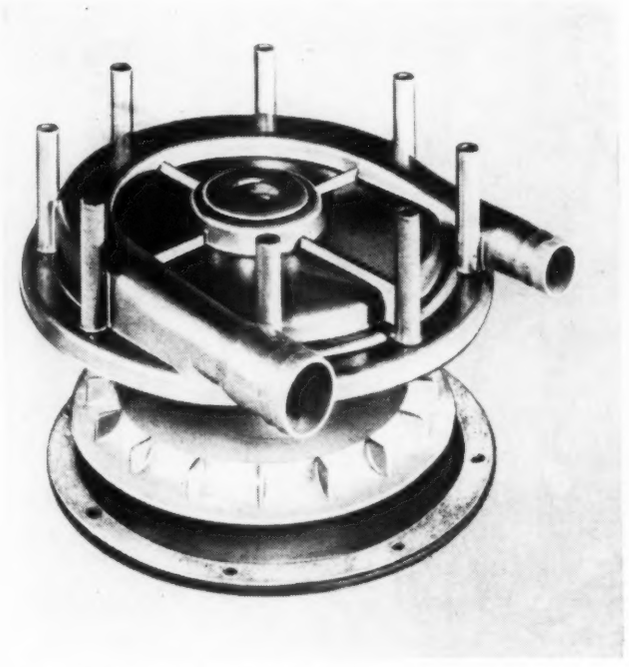
5 **RECIPROCATION** of the pulsator is accomplished by a crankshaft driven by the motor through a gear train. Rotation of the inclined surface on the end of the crankshaft causes the spindle to reciprocate vertically as shown. Pulsation is stopped during spin drying. The shift from pulsating to spinning action is made by electrical actuation of a spring clutch. The pulsator shaft has an up and down cycle of 330 strokes per minute. The tub assembly rotates at 1,130 rpm during the spinning operation.



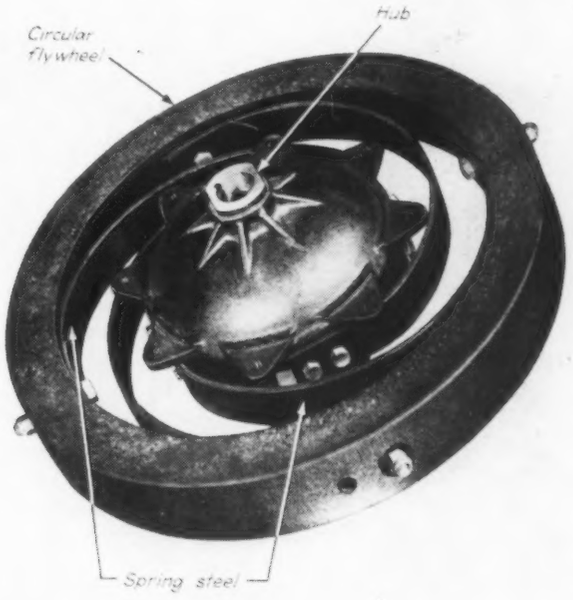
2 CUTAWAY VIEW of tubs shows the vertical mounting for the driving mechanism. Known as the Unimatic mechanism, the 1/3 hp motor and driving components are combined in one sealed, self-oiling unit. The water inlet control valve is electrically operated. At various times during the cycle it admits either hot or hot and cold water to the mixing chamber.



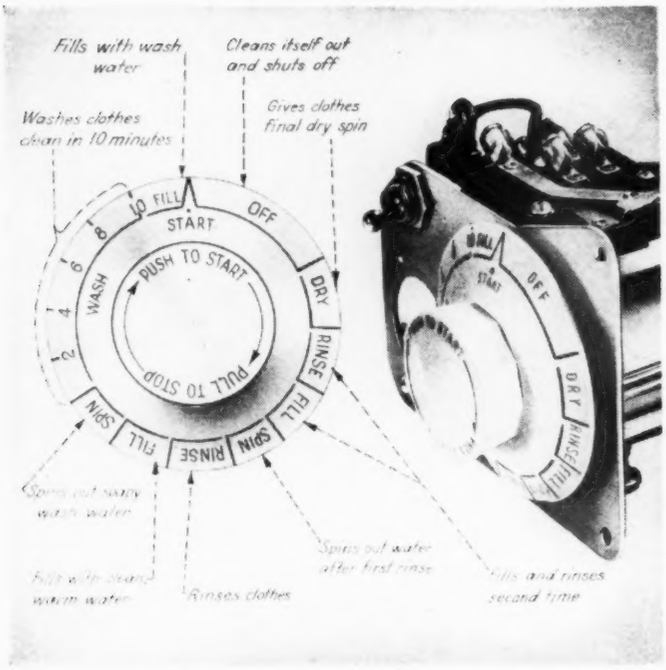
3 DURING PULSATION the Unimatic mechanism causes the pulsator to reciprocate vertically. The pulsator is perforated to release water during the spinning operation. An upper rubber ring on the pulsator serves to agitate the surface water. A water tight bulkhead is placed between the tubes and the motor compartment. A drain to the outlet is provided.



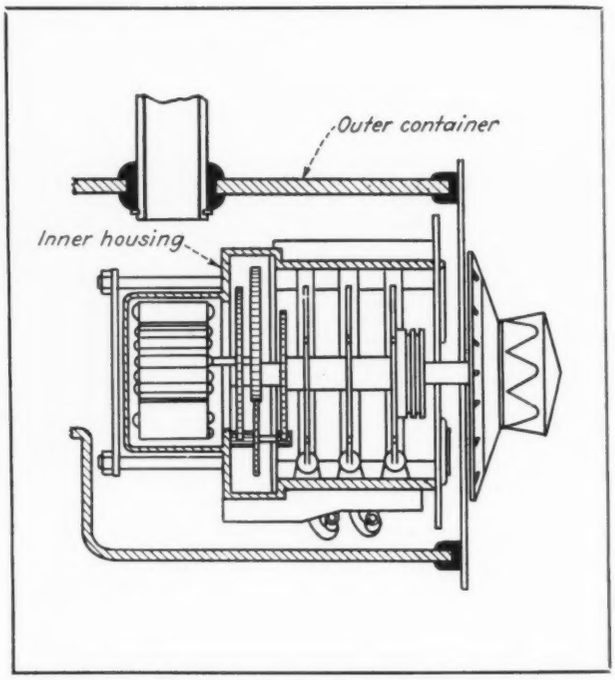
6 CLOG PROOF PUMP is bolted to the motor flange at the base of the Unimatic mechanism. This view shows the pump unit disassembled. Turbine type pump has a vaned impeller and has no screens, filters or valves. The pump revolves at the same speed as the motor. A fan for cooling the motor is mounted on the shaft between the motor and pump.



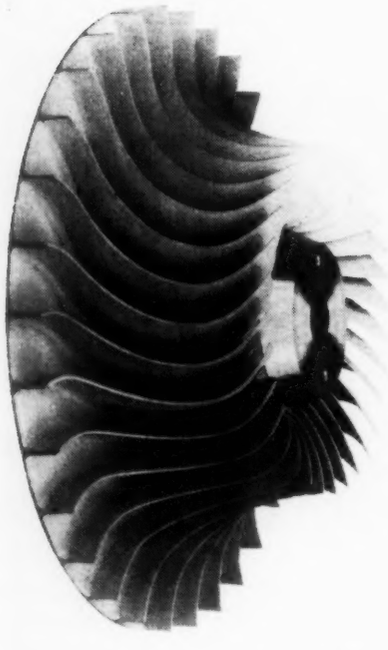
7 BALANCING MECHANISM permits high rotating speeds without excessive vibration. If a load of clothes settles to one side of the tub, the rotating pass is dynamically balanced by the harmonizer. The balancer consists of a flywheel connected to its hub by spiral steel springs. When unbalance occurs in the system the flywheel is displaced to counteract the condition.



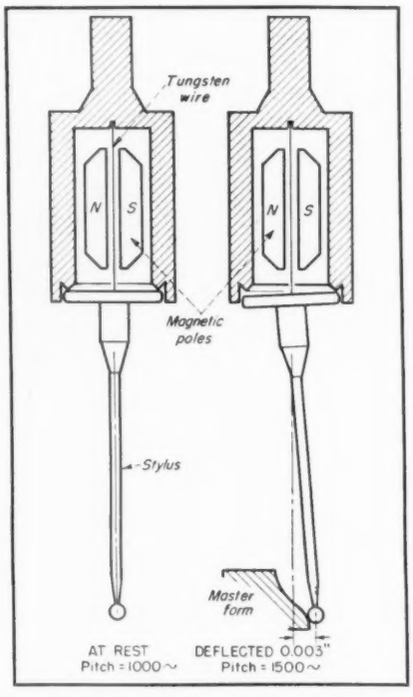
8 ELECTRICAL TIMING MECHANISM consists of a small synchronous motor driving a camshaft that acts on cam operated contactors. Sequence is automatic; but any operation can be lengthened, shortened, repeated or omitted by turning the control knob to the desired setting. Toggle switch can be operated to give either hot water at the system temperature or a 100 F mix for special washings.



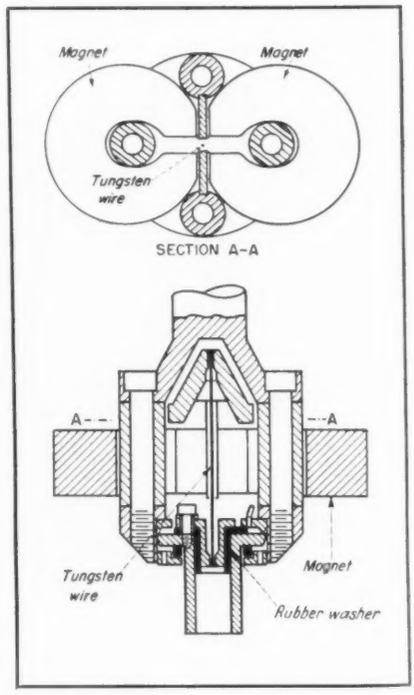
9 CONTROL UNIT is mounted inside two housings. The outer container protects the unit from moisture and soap. The inner housing supports the working parts and gives added protection. Pure silver contact points give high electrical conductivity. A fuse is mounted on the front of the control unit below the toggle switch. It protects the machine from overload conditions.



2 FOR ACCURATE duplication of contours, an indication of cutter pressure is required. The tone tracer permits accurate control of tracing pressure, even when using a long stylus. Formerly, many impellers were scrapped when thin sections were cut.



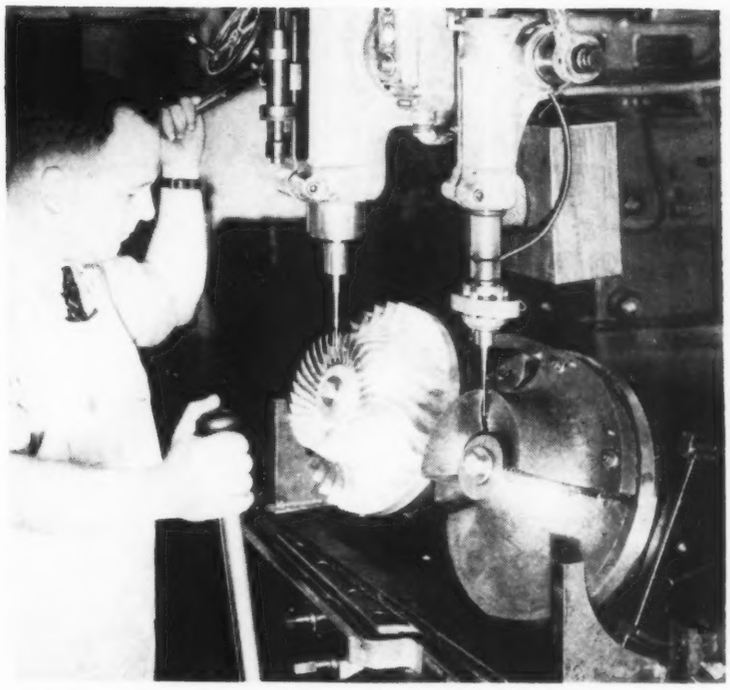
3 THE TONE is continuous but the pitch is variable. Pitch of the tone is proportional to the pressure applied on the stylus. Stylus length is such that a 0.0001 in. displacement will result from a pressure of a few ounces.



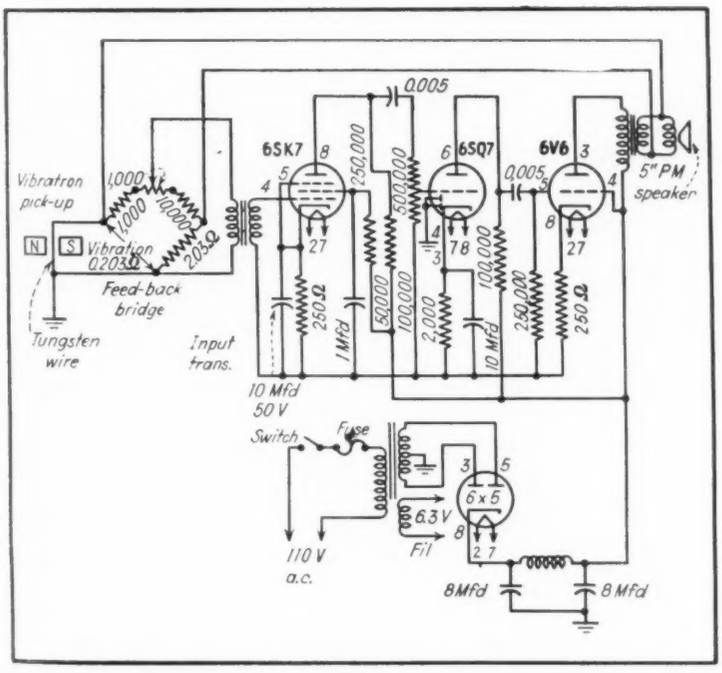
4 VIBRATION of the wire in the magnetic field causes fluctuating electric current to flow in the wire. Basic tone is adjusted without stylus pressure. Washer compensates for cutter deflection by allowing small movements without affecting tone.

Sensitive Pressure Indication With Tone Stylus

Applied tension, changing the natural frequency of a wire, stretched between two points, is the operating principle of this audible pressure-displacement indicator developed by the Aircraft Turbine Division, General Electric Company. Pressures that cause displacements of the tracer stylus as small as 0.0000001 in. are translated into audio signals.



1 THE EQUIPMENT aids in duplicating rapidly the deep contours and thin-walled blades of a turbo supercharger impeller, which are shaped by manual profile milling machines. Blade sections, 1/16 in. thick with these depths require a stylus about 4 in. long and 1/8 in. dia to trace the master form. A small pressure will bend this stylus 1/8 in. or more. The operator controls the machine manually by maintaining the pitch of an audible tone.



5 AMPLIFIER is hooked up with tracer head to give an audible signal to the operator. The tracer head, which is assembled in the tracer spindle in place of the conventional stylus collet, transmits stylus pressure displacement. Pressure exerted on the stylus above the pre-set pressure will increase the pitch of the tone. Audio system has high sensitivity. A 0.0000001 in. change in length of the 2 in. long tungsten wire changes pitch one octave.

Other Features

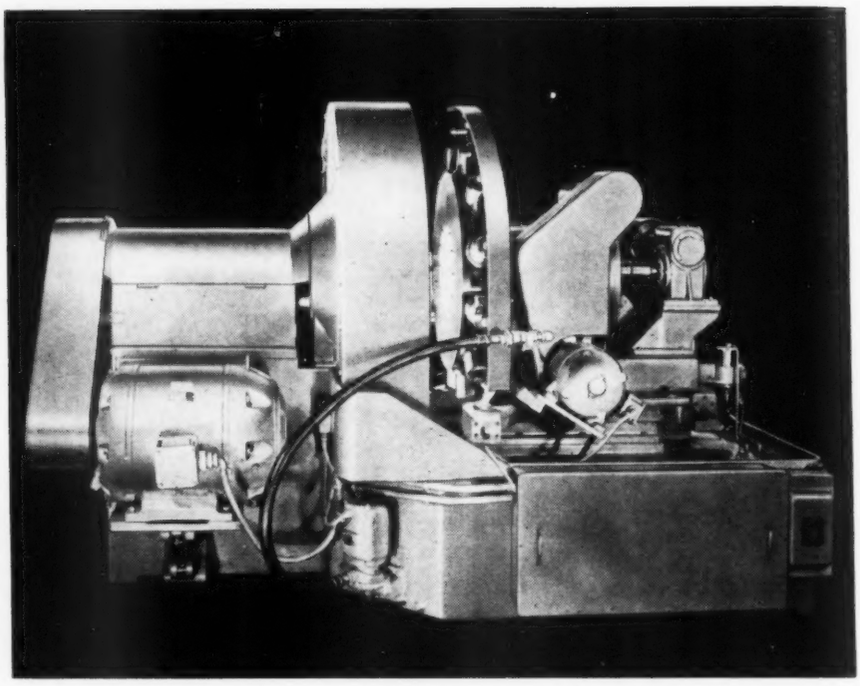
In following the intricate contour of the master form, the operator tries to maintain a constant pitch in the loudspeaker. After a short conditioning period, accuracy is several times greater than that possible by any other method. Final circuit has a feedback bridge to maintain the wire in vibration at all times during absence of outside vibration. This prevents the operator from being conditioned away from his "allowable pitch" region.

Sample Characteristics of Vibrating Tungsten Wire 2 in. Long, 0.009 in. Dia

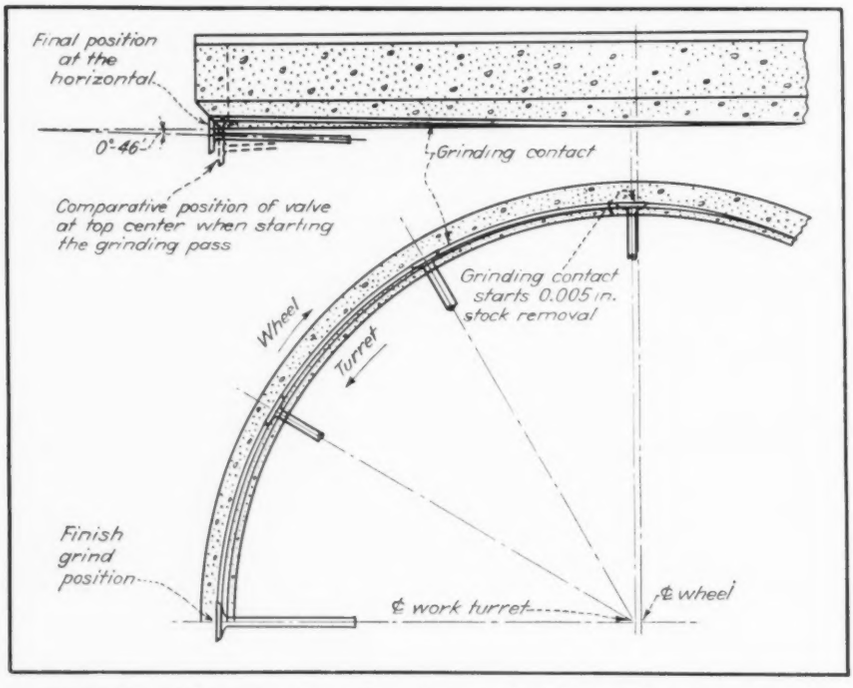
Deflection in.	Octaves	Frequency per sec	Tension psi	Load lb
0.000 000 08	0	32	2.37	.00015
0.000 000 16	1/2	45.25	4.73	.00030
0.000 000 31	1	64	9.46	.00060
0.000 000 63	1 1/2	90.5	18.92	.00120
0.000 010	3 1/2	362	302.9	.01926
0.000 08	5	1024	2407	.1531
0.01034	8 1/2	11584	310248	19.73

Oblique Alignment For Automatic Grinding

Developed by the Fitchburg Grinding Machine Corp., Fitchburg, Mass., this machine will grind automotive engine valves at the rate of 2160 pieces per hour. Parts of similar size can also be ground at comparable rates for mass production.



1 MACHINE CONSISTS of a vertical grinding wheel, belt driven from an electric motor; and a vertical turret that has 12 grinding spindles to receive the valves. Spindles are quill type, self contained, and they are driven by a 1 hp motor through a friction drive. The turret is driven by another 1 hp motor. The grinding wheel rotates at 5000 surface ft per min. Valves turn at 80 to 110 ft per min. The table carrying the turret has longitudinal adjustment for controlling wheel contact with valves.

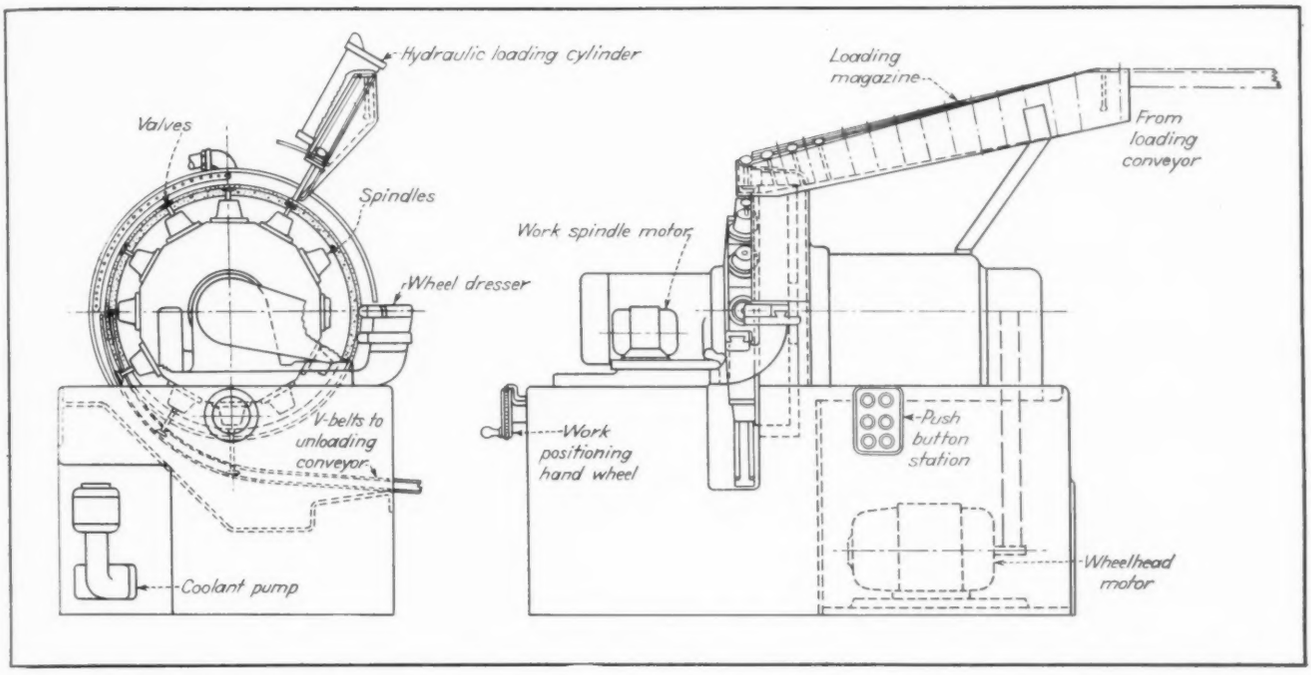


3 TURRET ANGLE for the setup illustrated is 0 deg 46 min. The wheel and turret rotate in opposite directions. The valve spindle rotation also is in the opposite direction to the wheel rotation. If a valve has more or less than the average amount of stock to be removed, it contacts the wheel either ahead of or behind the vertical centerline. Three valves are always in contact with the wheel. The grinding contact areas shown indicate how this method distributes wheel wear and gives a wiping action to remove burrs.

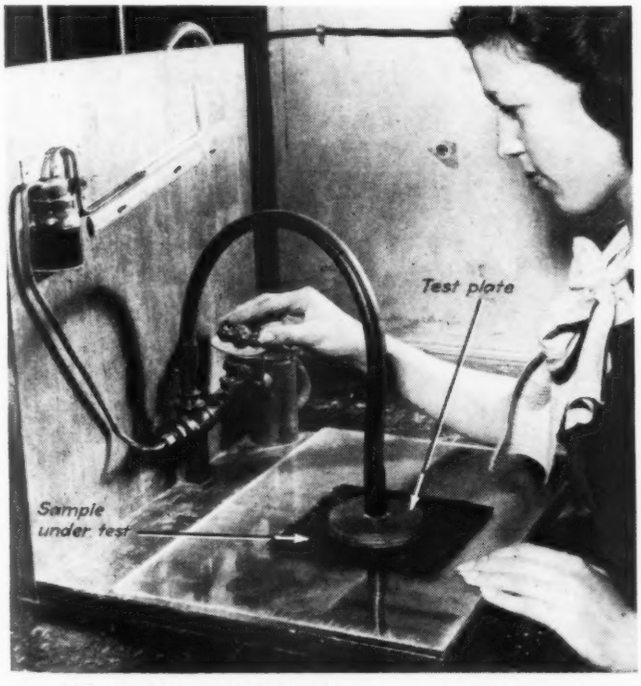
Surface Roughness Measured by Resistance To Air Flow

The Rugosimeter measures surface roughness of calendered raw rubber sheet. The property measured is the resistance to air flow between the surfaces of sample and test plate. The Rugosimeter was developed by Melvin Mooney, United States Rubber Co., N. Y.

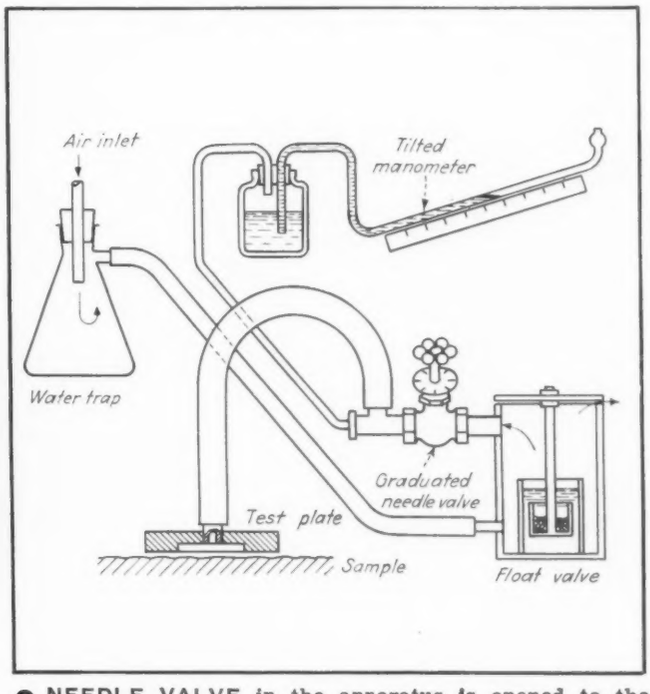
D E S I G N S



2 VALVES ARE GROUND to size as they pass through a 90 deg sector of the wheel face. Turret axis is set at an angle to the wheel axis by swinging the table that carries the turret and its driving mechanism around a vertical pivot. The angular setting is made so that at top center the grinding wheel face is separated from the valve face by a distance equal to the average amount of stock to be removed. Valves are inserted in the spindle collets by a hydraulically operated plunger. Collets are released by a cam in the center of the turret and valves fall out into a V-belt conveyor as they pass the horizontal center line of the wheel. The wheel is dressed at an angle that complements the valve face angle. Both spindle motor and wheelhead motor are mounted on the outside of the frame.



1 AIR FLOW RESISTANCE is converted to rugosity height: the height of the hills above the valleys in an idealized rough surface of sinusoidal profile. Calendered rubber surfaces are usually of a wavy type, with the rounded ridges and valleys approximately symmetrical about the median plane. Since surfaces are of similar type, a single figure gives comparative roughness.

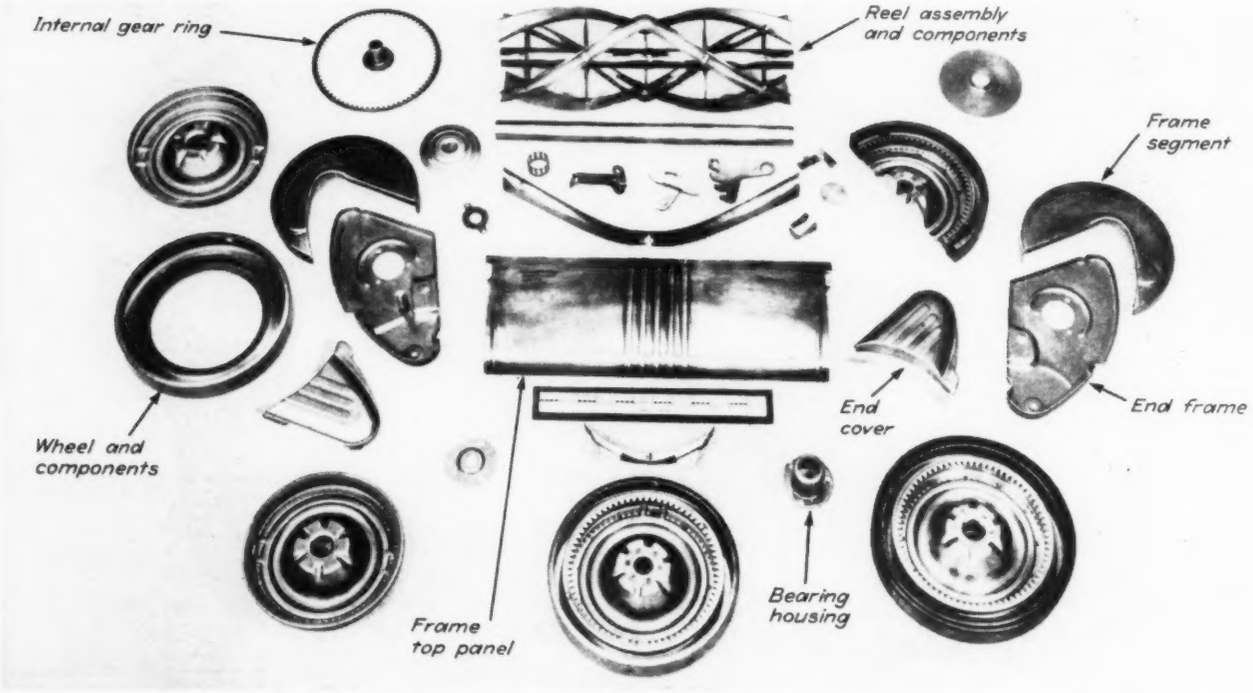


2 NEEDLE VALVE in the apparatus is opened to the point at which pressure on the manometer is one-half the pressure maintained by the constant-pressure valve. Resistance of needle valve to air flow is then equal to air resistance between test plate and sample. A reliable average figure usually requires measurements at five or more places on the sample.

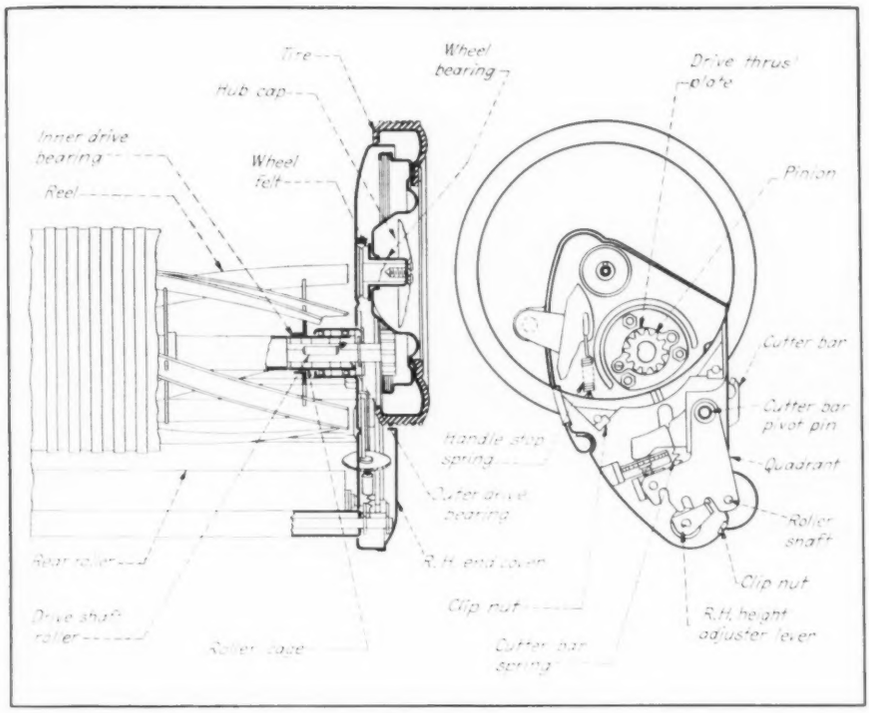
Sheet Metal Stampings Simplify Lawnmower Construction

Resistance welded sheet metal assemblies are used in the construction of a new lawnmower produced by Associated Manufacturers Inc., Waterloo, Iowa. Stamping designs were developed by the Acklin Stamping Co., Toledo, Ohio. Features include manual adjustment for both roller and blade, and spring loaded pivoted mounting that permits bar to disengage from blade during operation

1 **HERRINGBONE SHAPE** of reel allows two blades to contact cutter bar at same time and also permits high grass to be cut. Rubber tires are fitted over sheet metal wheels. Reel bearings are packed with grease for semi-permanent lubrication. Handle is a welded assembly of bent metal tubing. No tools are required for adjusting blade clearance.



4 **STEEL STAMPINGS** are used for the majority of the components of the mower. Reel consists of a welded assembly of a tubular shaft, spiders and blades. Blades are stamped from SAE 1035 hot rolled steel sheet 0.100 in. thick and hardened after assembly. End covers, end frames, frame segment and top panel are ribbed and drawn to shapes that give rigid members. Hot rolled steel stock 0.060 in. thick is used in the end frames, frame segment and top panel. End covers are made from 0.030 in. hot rolled steel stock. Hot rolled steel stock 0.050 in. thick is used in all the wheel components. Gear laminations are clinched to the gear holder by a press operation.

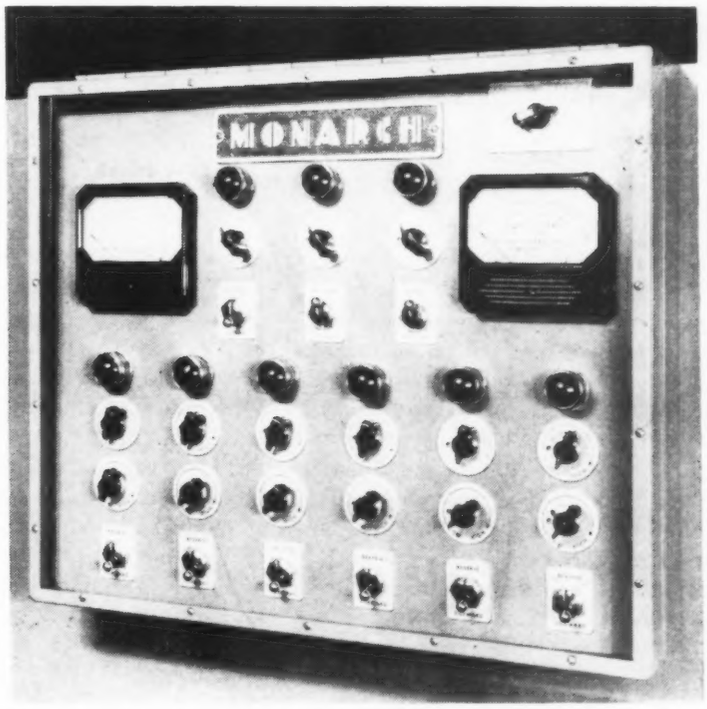


2 OIL IMPREGNATED BRONZE BEARINGS support the wheels, reel and rollers. The shaft supporting the back roller extends through the roller length. Reel drive consists of an internal gear on the wheel that drives a pinion on the end of the reel shaft. Adjustment for clearance between blade and reel is made by turning a notched wheel, each notch giving 0.001 in. change. Drive shaft roller serves as a key. Spring holds bar and wheel in contact.

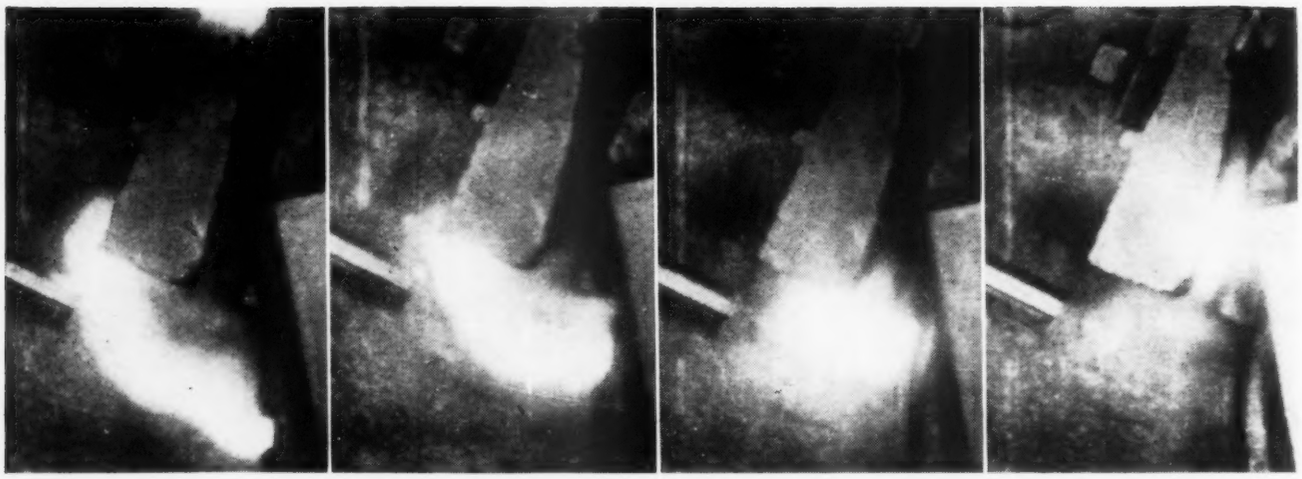
3 WHEEL is a spot welded sheet metal assembly of wheel hub, rim, gear holder and a laminated internal gear assembly. Gear laminations are clinched to the gear and spot welded in four places.

Compact Controls Reduce Set-up Time And Increase Machine Flexibility

A control panel on the Monarch Speed-matic Lathe has switches that operate an electronic system for selecting speeds and feeds. Manufactured by the Monarch Machine Tool Company, Sidney, Ohio, speeds and feeds for each turret and cross slide position can be quickly selected. Speed is read in surface foot measure.



CONTROL PANEL has visual feed and speed indicators. Surface feet is read directly by turning a switch to the work diameter. Forward or reverse spindle speeds from 50 to 5,000 rpm can be had. Operator indicator lights for each machine function are included in the panel. Speed and feed for each position are set automatically as the turret indexes.



Four successive views of copper contact showing different stages during the interruption of 200 amp at 125 volts d-c on non-inductive load. Views are from movie taken approximately 1,000 exposures per second during the laboratory test.

Characteristics of Silver and Copper For Use as Electrical Contacts

B. W. JONES
Control Engineering Division
General Electric Company

L. L. ZICKRICK
Research Laboratory
General Electric Company

Comparison of significant electrical and metallurgical properties of silver and copper materials when used for electrical contacts. Effect of sulphide and oxide films, current-resistance relationships, welding characteristics of silver and copper contacts, arcing properties, effect of heavy current on surface structure, and solder on contact tip are among factors discussed.

SILVER and copper are increasingly used for electrical contacts because of better understanding of their unusual electrical and metallurgical characteristics.

Among these, for example, is the current-resistance characteristic of silver and copper sulphide. As shown in Figs. 1 and 2, the resistance of silver and copper sulphide films on their respective base metals varies in such a manner as to first increase and then decrease the current. In Fig. 1 the data were obtained on the normally closed circuit, across terminals, of the double break type of switchette, and is representative of a test of all of the contacts of five switchettes tested daily for nineteen days. The switchettes were exposed with the covers off and it took 0.3 volts initially to break down the insulation film. In Fig. 2, the current increased and decreased as shown by the arrow marking on each curve. These data are for No. 1 size pair of contacts and a pressure of approximately 25 grams. The resistance of both silver and copper sulphide decrease very materially as the current increases, and then remains substantially at this lower ohmic value when the current is subsequently decreased. However, the ohmic value of silver sulphide for a given current is lower than that of copper sulphide.

The same characteristic of silver where the current is increasing from 0.5 to 100 amp is shown in Fig. 3. But if the contacts are opened after the above changes in resistance have occurred as a result of the different currents and then reclosed, the same change from high to low ohms will occur because of the same current change. For example,

With Contact Closed	
Amp	*Ohms*
1	0.055
10	0.008
1	0.008
Open, then Close Contact	
1	0.055

Unlike copper sulphide, this reduction in the resistance of silver sulphide is a stable reduction. Possibly this unusual resistance effect of silver sulphide is caused by some of its little understood composition properties, especially those of a thin film. For example, it is known that silver sulphide changes in electrical resistance at a remarkable rate with only a relatively small change in temperature. At 173 C the resistivity is of the order

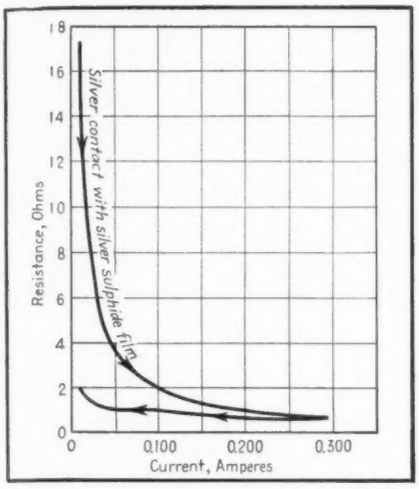


Fig. 1—Current-resistance characteristics for fine silver contacts in a switchette aged in hydrogen sulphide for thirteen days. Current is first increased from 10 to 300 milliamperes and then decreased over same range of current.

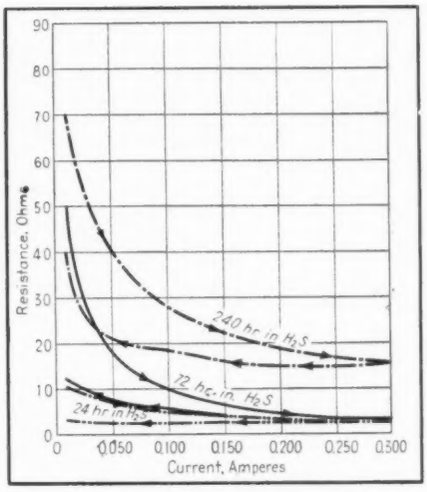


Fig. 2—Current-resistance characteristics of copper contacts aged in hydrogen sulphide for different time periods and tested on a pressure block at different current values. Contact pressure was one ounce throughout the tests.

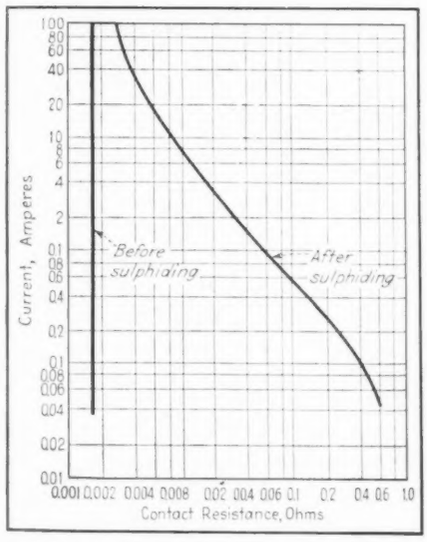


Fig. 3—Resistance versus current characteristic for silver. Contact size No. 2 in sample switch was aged in a strong sulphiding atmosphere for 48 hours to show relative change involved.

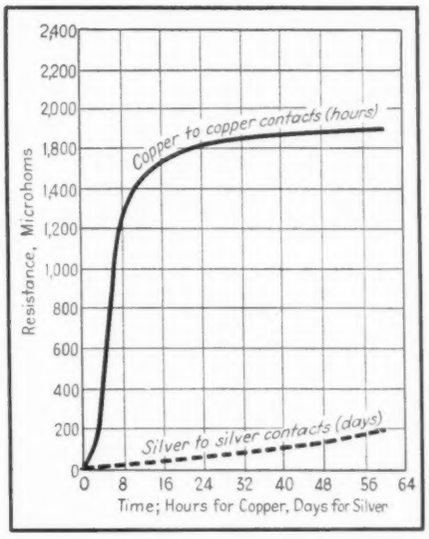

Resistance, Microhms
Copper to copper contacts (hours)
Silver to silver contacts (days)
Time; Hours for Copper, Days for Silver

Fig. 4—Contact resistance of copper and silver contacts when held at 20 psi pressure. Contact faces kept apart while in an 85 C oven and contact resistance periodically measured.

of one one-thousandth of what it is at room temperature, and at this temperature the form changes from what is termed beta to the alpha form of much lower resistivity.

Silver sulphide is considerably softer and more plastic than similar tarnish films on base metals, being of the order of lead. Its softness helps make it easy to remove from any abrading or sliding action.

Silver, unlike copper, does not oxidize under ordinary conditions. But if the oxide film does appear on a contact surface, it will readily decompose and leave pure silver. This reaction is caused by the heat generated in the tips from the current passing across the contacts. Decomposition of silver oxide proceeds rapidly at an approximate temperature of 300 C, and as the oxide is reduced the contact resistance is reduced appreciably.

Pure silver oxide as manufactured chemically is a very fine, soft, brownish-black powder somewhat like soot. Its electrical resistivity, like that of other metal oxides, is extremely high. Bars pressed from the pure oxide powder under heavy pressure give resistivity values ranging up to 45 megohms per cu cm. The idea that silver is a good contact metal because its oxide is a conductor is not substantiated by experimental data.

But pure silver with the surface in the proper condition is readily oxidized by ozone, O_3. The oxidation is instantaneous and the resulting film appears bluish black, smooth, and is at first extremely adherent. On thin silver strips the film is quite tenacious. At 400 C one or two minutes are required for complete decomposition to restore the silver to its original bright state. On contacts used where high voltages are involved, and especially if a glow discharge occurs, there may be sufficient ozone generated to "tarnish" the surfaces of silver tips.

Therefore neither the sulphide nor oxide of silver appreciably impairs silver as a good contact material. Tests have shown that 10 volts or even less, will generally puncture the sulphide surface films that form on silver contacts. But copper behaves differently. Copper oxidizes rapidly, as shown in Fig. 4, especially at elevated temperatures. The copper oxides CuO and Cu_2O are not reduced by heat. On the contrary these films increase with temperature, thereby causing the contact to increase in temperature and thus creating a cumulative condition. This resistance can increase to such a degree that it will insulate the contacts against voltage as high as 125 or 250 volts.

When copper contacts are bolted together under high pressure, there is no increase in contact resistance because the two mating surfaces cannot oxidize.

The welding characteristics of contact materials can be determined by "Tentative Method for Life Test of Electrical Contact Materials", American Society for Testing Materials, Designation B 182-43T. The testing machine has three pairs of contacts, each of which make and break a 110-volt a-c load once per second. The contacts are ¼ in. in diameter, the closing force is 100 grams and the opening force is 75 grams. The value of the current that cause the contacts to weld under these conditions is determined for each material.

One hundred thousand operations per pair of contacts are made for each condition of load and generally there are three or four conditions for each

material. From these 100,000 or more makes and breaks, four significant characteristics are checked:

1. The "no-weld" current rating. This is the value of current that will just keep from welding any one contact material during 100,000 operations.

2. The average strength of the welds at a current near the no-weld current.

3. The loss of weight of each material when making 100,000 operations at or near the no-weld current.

4. The relative energy of the arcs of different materials. This is reflected in an approximate manner by the temperature attained by the contact tips.

When silver contacts are used the machine can run 100,000 operations making and breaking 24 amp at 110 volts, 60 cycles, without any welding of the contacts.

With copper contacts this current will cause welding. Also the arcing at the contacts will result in sufficient oxidation to insulate the tips and cause open circuit.

Nickel of higher specific resistance can make and break a maximum of only approximately 6 amp without welding.

Test results for the no-weld ratings of several contact materials are shown in Table I.

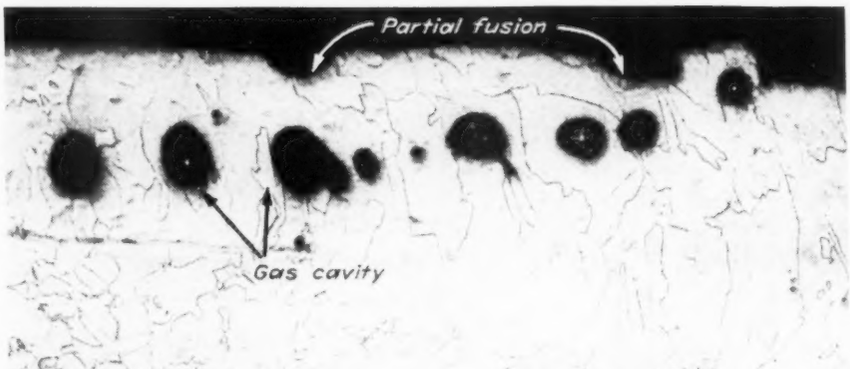
Table I—No-Weld Ratings of Different Contact Materials

Material	*No-Weld Current, amp.*
Tungsten	35
60 Molybdenum-40 Silver	26
Silver	24
90 Silver-10 Iron	23
85 Silver-15 Cadmium	21
Nickel	6
75 Silver-25 Zinc	4
Copper: Oxidation causes open circuit	

It is interesting that silver is one of the lesser weldable materials on low currents of the order of 25 amp, but is one of the more easily weldable contact materials on the higher currents such as several hundred amperes. One explanation is that its high conductivity of heat makes it difficult to raise any appreciable amount of the surface metal to the melting point with a low current. Since the specific heat of silver is only about half that of copper, and it is in the low range for the contact metals, its high conductivity does not compensate for its low specific heat when carrying the higher currents.

Magnification 100

Fig. 5—Effect of excessive local heating on copper contact tip of d-c controller operating on 140 amp, 250 volts, inductive load; 125,000 operations, 20 per min.



Magnification 100

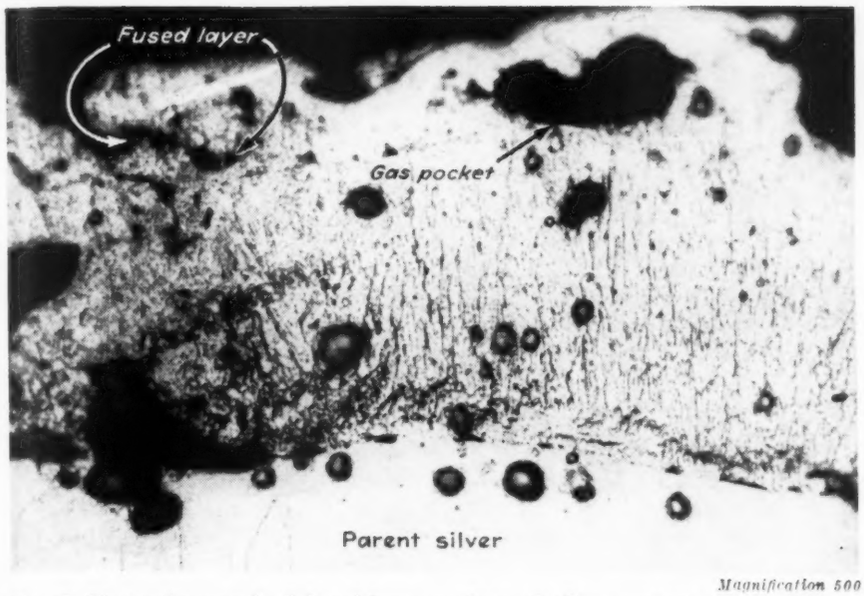
Fig. 6—Contact tips operated in oil. Size No. 1 contactor interrupting 70 amp stalled 440 volt a-c motor load six times per minute for 60,000 operations.

In general it is believed that the four important factors affecting the tendency of a metal to weld are: (1) Specific resistance, (2) specific heat and thermal conductivity, (3) melting point, (4) oxidation resistance.

Arcing Characteristics

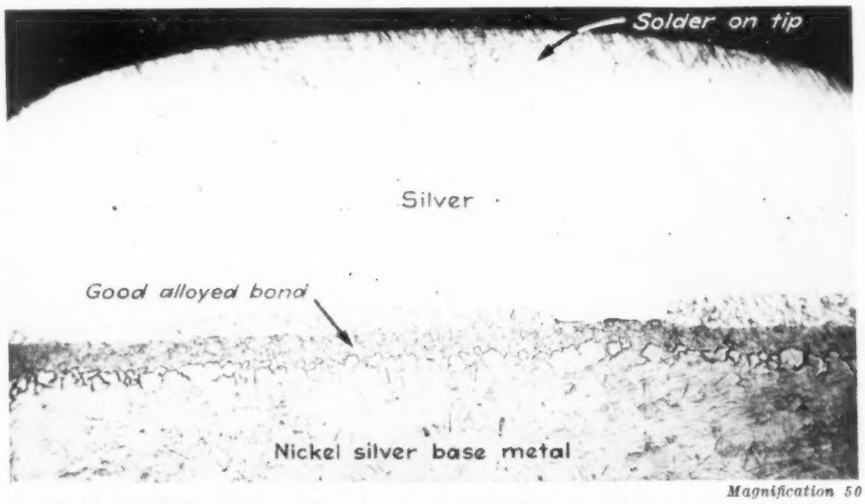
If 25, 50 and 100 amp direct current are permitted to arc between copper contacts that are separated approximately 100 mils or 0.100 in. between tips, the initial value of voltage that will appear as the contacts begin to separate will be 12, 13, and 14 volts respectively. The voltage for silver will be 12, for all three. The voltage reached at the end of the 100 mils travel will be 27, 28, and 29 volts for copper, and 32, 33, and 34 volts for silver. The time duration will be in the order of several milli-seconds. This gives an indication of the order of magnitude of energy that appears close to the surface of the contacts when an arc is drawn, how much metal is melted, and how much is vaporized if all the energy remained at the spot where the arc is struck.

High temperature on the surface of any cold metal is rapidly lowered by



Magnification 500

Fig. 7—Photomicrograph of fused layer on face of silver contact, operated short time on currents varying from 220 to 380 amp, 200 volts, direct current.



Magnification 50

Fig. 8—A good bond, but alloy has accidentally contaminated contact tip surfaces. Contamination from soldering or flux may cause faulty operation.

the surrounding cold metal. But the thermal conductivity, the specific heat, the melting point, and boiling point, together with the heat of fusion and the heat of vaporization are all factors that produce a given effect.

If these two metals are permitted to arc during one half cycle of time and the value of voltage required to re-establish the current for the second half cycle is then ascertained, the result will be a measure of the arc extinguishing characteristic of these two metals under this condition. With a reactive load of 50 percent power factor and an impedance of approximately six ohms, copper begins to re-establish on 320 root-mean-square volts while silver required 440 volts on the same contactor. This shows that silver has the more desirable characteristic in this respect.

Effect of Heavy Current

The crystal structure and condition of the face of a contact tip may become altered after operating under heavy load conditions. A photomicrograph showing a simple condition of a copper tip whose surface has been altered from that of the underlying metal is shown in Fig. 5. It shows that local surface heating caused the formation of excessively large grains, partial fusion, and formation of some gas inclusions. This altered structure extends to a depth of about 10 mils, or 0.010 in. Continued operation of copper tips under such conditions also causes the formation and growth of copper oxide layers, occasionally as much as several mils thick.

The surface cross section of copper tips of an oil immersed contactor operated 60,000 operations in oil is shown in Fig. 6. Oil operation produces a rate of wear about 40 to 50 times that of similar tips operated in air. The photomicrograph facilitates a greater understanding, even though it does not explain the reason. A comparison of the surface with the fine grain structure below shows that the surface operated at excessive local temperatures. The high temperature caused partial fusion with formation of considerable porosity from gas cavities. These are formed by (1) absorption of gas from the arced oil at high temperature, followed by (2) ejection from solution during the extremely rapid drop in temperature after the current is interrupted. Subsequent operations with instantaneous high high surface temperature easily tear this weakened structure, possibly aided by sudden expansion of gas contained and trapped in the tip surface.

The deposit of a fused layer on the surface of a silver tip operated at about 300 amp direct current is shown in Fig. 7. This layer of 0.002 in. thick metal was molten and then resolidified on the silver surface. Such a deposited layer may become the contact surface during subsequent operations, giving poor contact, causing higher temperatures than normal, and result in an increased rate of wear.

Solder and soldering flux are used commonly for soldering or brazing contacts to their supports. During this process the flux or solder may get on the surface of the contacts.

It has been found that this solder contamination will cause failure to make circuit and may also cause the contacts to weld more readily than will the pure silver or copper. Therefore, care and caution should be used in design to prevent such contamination. When practicable, the use of soldering operations should be eliminated. A silver contact tip is shown in Fig. 8 that is contaminated with solder on the working surface of the contact area.

Progress IN REVIEW

PLASTICS

Centrifugal casting of fast-curing phenolics in inexpensive dies makes possible many new plastic applications. As reviewed in the September 1947 issue of *Modern Plastics,* outstanding uses include the production of prototypes, sales samples, or short-run orders; the casting of industrial tools such as form dies or duplicating patterns; and the production of parts too large or too thick for other types of molding. The phenolic parts, cast on low-cost plaster negatives, resist scratching, grooving and chipping.

Plastic belting, designed in Switzerland where it is being used to transmit power on the small tools of the watchmaking industry, is now available in the United States. Its physical properties are such that an endless belt is created by merely touching the two ends to a surface heated to 300 F and pressing them together. No mechanical fasteners are necessary and should the belt stretch, a section can be cut out and a new joint made. It is claimed that this plastic is not affected by oil, age or reasonable heat. The belting is available in round, trapezoidal and flat shapes of various sizes.

Expanding inserts, for use in formed or drilled holes in molded plastic parts, can be used at any time after the molding process. According to *Plastics News Letter,* September 1, 1947, the torque and pull strength are comparable to molded-in inserts. Molding troubles are minimized, rejects are reduced, production rates are increased and mold damages are reduced because misplaced inserts are avoided. The inserts are tapered for easy entrance and are tightened by an expanding washer.

Rapid production rates have keynoted recent plastic developments in England. As reported by *Plastics* (London), August 1947, a new miniature camera has been designed so that a complete set of plastic components are produced in one mold—a new camera being formed every 40 seconds. Made of black cellulose acetate, the complete camera with shutter, lens and metal eye-level viewfinder weighs only 1¾ ounces. It takes 1/2 x 2/3 in. pictures that can be enlarged up to 5 x 7 in. without loss of detail. An American counterpart, described in the September 1947 issue of *Plastics,* is manufactured from five molded phenolic parts. The housing and cover are made with low tolerances that provide a light-tight fit which can be held by a handbag-type clasp closure. The parts are molded with a dull inner finish to avoid reflected light within the camera and the outside surface is a simulated leather finish. The advantages include: Low cost, ease of assembly, light weight, and the elimination of painting and polishing. The phenolic components provide adequate insulation for the electrical assembly of the built-in flash synchronizer.

Basic functional design, using plastic materials, is well illustrated by an article in *British Plastics,* July 1947, and by L. Laden in the August 1947 issue of *Plastics.* In England, two-tube a-c and d-c radio receiving sets, weighing 3 lb and containing 15 major components and over 35 minor conductances, are produced in 30 min with little human labor. The radio was designed as a composite of chassis and circuit, instead of the usual box full of parts, which brought about optimum use of a minimum amount of materials. A phenolic shock-resistant powder is used to mold a 7 oz chassis, 6x6x¼ in., with molded-in grooves, depressions and webs that later serve as the circuit. The chassis is then fed into a 70 ft. electronically-controlled machine that, in 20 sec. automatically performs the following operations: Grit blasts all surfaces of the chassis; applies metal to fill grooves by use of four rocking, spray metal guns; removes excess metal; sprays on liquid graphite solution through stencil-indexed screening masks; inserts socket-holders and sockets by clinching, riveting, welding and soldering; seals, lacquers, cleans, dries and tests the circuit. Some manual assistance is then used to plug in tubes, to affix loudspeaker and cords; and to mount rectifier and amplifier circuits. The circuits are rechecked and the unit is manually inserted and fastened within a molded phenolic cabinet. The articles are illustrated to show how the radio was designed as a new unit instead of a re-styled standard unit.

Duplicate molds as large as 80 sq in. can now be quickly hobbed, at low cost, with the new 8,000 tons Elmes press. According to *Modern Plastics,* September 1947, the press weighs 90 tons, is 15½ ft high; and has 39½ in. diameter ram that travels a maximum stroke of 18 in. at a rate of 6 in. per min under load, and 11 in. per min unloaded.

Thermoplastic sheets have been softened, prior to pressing and blowing operations, by the use of radiant heat. With various horizontal and vertical arrangements of the infra-red lamps, as reported in the August 1947 issue of *Plastics* (London), measurements were taken to determine heating times required to raise the plastic temperature to a specified point. The process was carefully analyzed to determine the costs of heating and the practicability of automatically controlling the end temperatures. This article also presented the effects introduced by the color of the plastic. The data should be of value in many thermoplastic applications; including the use of polyvinyl chloride pastes for fabric coating.

New raw materials for producing plastics and adhesives have been developed from the bark of the Douglas fir. In an effort to separate the cork known to exist in the bark, according to E. Marple, *Plastics,* August 1947, it was found that other materials in the bark were even more useful. Three bark components are used to make five products now being marketed. Fiber, cork and powder are the pure materials, and combinations of cork-fiber and cork-fiber-powder make up the other two. The first and the last two are used in plastics, and the last one is used as an extender in phenolic resin and protein

adhesives in the bonding of plywood. These materials are important as a domestic raw material because the thick bark represents 12 percent of the most important saw log in the Pacific Northwest. The barks of other Pacific Coast conifers are useable, but must be processed separately because of differing chemical and physical properties.

Vinylite floor covering, known as Flor-ever, has a waterproof, asphalt-impregnated backing. This material, priced competitively with linoleum, can be put down with the same ease. In fact, identical glues are used to lay both coverings. The color in the vinylite covering goes all the way through and, according to *Modern Plastics,* August 1947, the material is available with solid or mottled coloring. The manufacturers guarantee Flor-ever against cracking and chipping, and claim that it will resist the actions of fruit juices and soap.

Plastics used correctly in combination with other materials is illustrated by an article in the August 1947 issue of *Plastics.* An accordion has been produced that contains 27 plastic parts representing eight chemical types. These plastics include thermosetting and thermoplastic, filled and un-filled: nitrocellulose, acrylic, butyrate, acetate, styrene copolymer, molded phenolic and laminated phenolic types. The accordion was designed with these new materials to help eliminate dimensional changes caused by temperature and humidity variations. Other advantages were obtained because of the light weight, durability and permanent color appeal of the plastics chosen. The function of each part was carefully investigated before the type of plastic was specified.

Friction cutting techniques, well known to the metal trades, have been found useful in parting ceramic plastics. As indicated in *Modern Plastics,* August 1947, ordinary sawing practices are not feasible because blades dull too rapidly. With friction cutting, work pressure heats and softens the ceramic, which is then parted by rounded-off cutting edges. A 14 pitch, ½ in. wide saw band, moving at a velocity near 10,000 ft per min, will cut a 1 in. plastic slab at a linear rate of 10 in. per minute.

Processing variables can have a large effect on the physical properties of finished plastic parts. Suppliers of plastic materials frequently report the average, maximum or minimum properties that can be expected if materials are used in certain manners. Frequently, as mentioned by J. Delmonte, *Plastics,* August 1947, fabricators do not obtain these properties because they have used improper processing methods. Working at elevated temperatures is frequently deleterious; improper calendaring fails to produce the desired orientation; improper mold design leads to weld marks, flow lines, lack of orientation and decreased strength. With proper study, greatly improved properties can be obtained. Tensile strength can be increased or decreased 50 percent just by varying technique; drawing of nylon increases tensile strength by as much as 400 percent. Aging is not always disadvantageous as the aging of Saran gives improved properties via gradual changes to crystalline structure.

Physical properties of nylon have been compared with those for Saran, glass, manila, sisal and cotton in a review of rope and rope-like materials appearing in *Modern Plastics,* August 1947. Nylon was found to be outstanding in strength, abrasion resistance, impact strength, and resistance to water, sun and rot. Because of the higher cost of nylon rope, it has replaced other types only where the added safety and life justify the higher cost.

Mandatory use of GR-S synthetic rubber, 300,000 tons annually, has been demanded by many experts, but R. F. Wolf suggests, in *India Rubber World,* August 1947, that forced use and government subsidy of the industry are not necessary. He indicates that competition on a cost and merit basis will insure a synthetic rubber supply for any emergency. The plants designed to produce the GR-S raw materials need neither close nor crumble, even if no GR-S is produced. The butadiene plants can be used to produce high octane fuel and the styrene plants can manufacture for the plastics industry. The fact that synthetic rubber production could be started in a few months would tend to stabilize the price of natural rubber and would keep the United States prepared against any scarcity of natural rubber.

Fine mechanics of elasticity have been studied through use of shadow techniques. The shadows cast by tiny rubber particles during elongation, invisible through the ordinary microscope, can be studied with the ultramicroscope. The studies of E. A. Hauser, *Rubber Age,* July 1947, indicate that elasticity is not specific to a certain chemical class but arises from the proper mixture of small-molecule liquids and hig molecular weight, thread-like solids.

Airless abrasive blasting is the latest metal-working technique to be successfully applied to the rubber industry. The talc dusted on sponge rubber parts prior to molding often leads to poor adhesion when the parts are to be cemented into place. The new process, as reported in *Rubber Age,* July 1947, removes the mica and roughens the surface in from one to five minutes.

Rubber-in-twist springs provide the smooth riding characteristics of new sectioned-body busses. The busses, with over-all lengths of 47 ft, are equipped with Goodrich Torsilastic springs at the wheels and at the hinge separating the two sections. The springs, described in the July 1947 issue of *India Rubber World,* are made of steel shells mounted on an axial steel shaft. The space between the shells is filled with rubber, bonded to each steel member.

Rubber-to-metal adhesives based on isocyanate or urethane resins, mentioned in *India Rubber World,* July 1947, were used by German industry to mount treads on tank tracks. In line with this is a discussion of the Ty-ply adhesives in the July 1947 issue of *Rubber Age.* For best results, the type of adhesive must be specified for each synthetic rubber. Though definite directions must be followed when using these adhesives, the methods are simple when compared to the brass-plating process.

NONFERROUS METALS

Cast and extruded magnesium have been studied to determine their mechanical properties at −70 C and at room temperature. The alloys were tested in the "as cast" and solution-treated condition and in the annealed state. The tests indicated, D. E. Dineen and N. D. Benson, *Metal Industry,* August 1947, that there was little difference between tensile strengths at room temperature and at −70 C for the Mg, Al, Zn, Mn alloys, but that alloys of the Mg, Zn, Zr type showed a marked increase in strength at the lower temperature. Elongation and reduction of area were lower in all cases at the lower temperature. The zirconium containing alloys had better impact resistances than the other alloys at both temperatures, whether tested as notched or un-notched specimens. There was slight loss in impact strength of the un-notched specimens at −70 C for all of the alloys.

Super metals will have to be designed to meet the growing needs of military and industrial requirements for propulsion and power generating machinery, according to an address by C. E. Williams given before the ASME on Sept. 2, 1947. Such materials will have to withstand temperatures of 1,600 F, or higher, at stresses as great as 20,000

lb per sq inch. While many of these "super alloys" will be iron base materials, it has been pointed out that the strongest materials now available for casting gas turbine blades are precision castings made from cobalt base alloys, containing 40 to 70 percent Co, with additions of Cr and Mo. Also showing promise, at even higher temperatures and stresses, are alloys containing 50 percent or more of chromium. One of the most promising alloys contains 60 percent chromium, 15 to 25 percent molybdenum and the balance of iron. Melted and cast in a vacuum furnace, it is even better than the cobalt base alloys, on the basis of preliminary tests.

Die-cast aluminum alloy combination sinks 41 x 15 in. containing an 8 in. deep sink and a 28 in. long drain board are being manufactured in England. Normal usage has brought about no staining on test samples over a period of one year. Soap, steel wool, salt brine, alkaline cleaners and other kitchen products made light brown stains that were easily removed. Except for scratch brushing of the surface, the sinks were unfinished. As reported by *Light Metals*, August 1947, they were joined to the brass drain pipes by conventional methods, but in a year's service no visible corrosion was evident.

Low-cost aluminum dies, capable of forming intricate designs, deep draws and close tolerances at 10 percent of the cost of the former steel dies, have broadened the use of low pressure plastic molding techniques. In addition, the use of a mold liner makes it possible to replace the liner instead of the entire mold. These molds have been successfully used to produce phenolic, deep-drawn shoe racks, which hold and convey shoes on a mass-production assembly line. The plastic racks are superior to the former type because the best design characteristics were molded into them. They do not scratch the leather shoes and are easily kept free of shoe dyes.

Zirconium added to magnesium base alloys has increased the speed at which these alloys can be extruded. One of the newer and more promising alloys, discussed by J. C. McDonald, *Metal Progress*, August 1947, intended for use in extrusions, contains Zn, 5.8 percent, and Zr, 0.8 percent. In addition to improving the extrusion rate, the added zirconium produces an extremely fine grained structure in the cast billet, which insures a fine grain size in the finished product. The fine grain structure gives a product that is very tough. By varying the zinc content in alloys containing more than 0.5 percent Zr, a series of alloys is produced with varying physical properties. Small amounts of cerium added to magnesium base alloys impart increased resistance to creep, particularly at elevated temperatures. This should make magnesium alloys more suitable for engine applications and other high temperature uses.

Radioactive isotopes, produced in large quantities, as a byproduct from uranium piles, are expected to be a powerful tool for aiding in the solution of many metallurgical problems. Because the radioactivity of these isotopes is indestructible, detectable in small quantities, detectable at a distance and peculiar to the isotope in question, they can be used to study reactions at the slag-metal interface of the open hearth steel furnace and to explore the crystal structure of complex non-ferrous alloys. Radioactive isotopes should greatly facilitate the studies of wear and fatigue.

Olite bronze inserts have been found to be the best for use in magnesium alloy castings, according to a report in the August 1947 issue of *Light Metals*. Such inserts resulted in less corrosion in the standard salt spray test, 26 hours, than did "410" corrosion resistant steel, manganeses bronze, zinc-plated carbon steel or unplated carbon steel—arranged in descending order of merit. In another series of tests, it was found that cast aluminum parts containing carbon-steel inserts, which have to be masked in order to permit anodizing, could be given the Alrok treatment without masking, after which the corrosion resistance was comparable to that of the anodized castings. The alloys studied included 40E, Alcoa 195 and Alcoa 356. Bare inserts caused the greatest amount of corrosion; cadmium plated steel inserts caused only about half the corrosion found with zinc-plated parts.

Aluminum scrap, long of questionable value to the aircraft industry, can be remelted and refined to form good sheet meeting aircraft specification requirements. Starting with charges consisting of only 20 percent scrap, according to G. W. Birdsall, *Steel*, August 4 and 21, 1947, one of the large metal companies is now using 100 percent scrap and still meets purity requirements. Improved fluxing, resulting from the development of the continuous introduction of gaseous chlorine into the molten bath of remelted aluminum, is regarded as one of the important factors in this achievement. This process is so successful that reclaimed metal can easily be remelted and brought to the definite composition ranges for 17S and 24S, simply by the addition of the alloying elements. Such metal is suitable for rolling mill or forging shop use without the addition of new aluminum. The method is adaptable to sheet as thin as 0.20 in. with a recovery of 96 to 98 percent. In practice, a reducing flame is used in a sloping hearth furnace that will not melt iron or copper, and from which the aluminum can be drawn periodically. This process provides for the continuous addition of the chlorine, eliminates the need for mechanical agitation, permits a nearly continuous remelting and refining cycle, and provides maximum output.

Stampings required for experimental runs are being produced using dies made of a low melting alloy of bismuth, tin and lead. As mentioned in *Iron Age*, Sept. 11, 1947, a limited number of stamped parts can be made quickly and cheaply in these dies. Such an alloy would not ordinarily withstand die pressures, but by dipping the dies in a bath of liquid nitrogen at approximately —320 F, the surface hardness is increased sufficiently to permit the making of 6 to 10 stampings before rechilling is necessary. By using this technique, experimental stampings can be obtained in 24 to 48 hours instead of the usual six to eight weeks.

Silver plate has been used on steel parts to facilitate the bonding of steel to glass. As mentioned by N. S. Freedman, *Steel*, August 25, 1947, this process was developed for use in manufacturing small, high frequency tubes. The silver layer possesses good glass-sealing properties and has suitable conductivity while the steel has a thermal coefficient of expansion comparable to that for glass.

Magnesium has been used to replace the fabric coverings for some aircraft parts such as flaps, ailerons and elevators. By using magnesium skins: 0.020 in. of FS-1H alloy sheet for the ailerons and elevators, and 0.025 in. stock of the same alloy for the flaps, the number of parts in these controls has been reduced from 439 to 102 per ship. Such controls, as reported by R. E. Saunders, *Materials and Methods*, August 1947, showed less than half the deflection under load tests than did the fabric covered parts, and withstood much greater loads without any visible sign of buckling.

Porosity of aluminum alloy castings has been studied to determine the effects caused by water vapor and the products of combustion produced by the various fuels used. In general, porosity—particularly pinhole porosity—has been attributed to the separation of hydrogen from the molten solution as the metal solidifies. This porosity, as pointed out by C. C. Griffin and L. C.

Stephens, *Metal Industry of London,* August 15, 1947, is usually found around the dendrites. Pinhole porosity has been found in castings made from metal melted under a controlled flux; from metal melted in oil-fired furnaces, with or without injected water vapor; from gas-melted materials and from gas-melted material blanketed with dried air. Castings made from a coke-fired melt and those made from an electric furnace melt have been found sound. It has been concluded that water vapor formed during combustion or introduced in the air is a potential source of pinhole porosity. Since coke-fired melting has not been found practical, care should be taken to reduce the amount of water picked up by fans, blowers and oil storage tanks. A special flux that will dissolve and combine with the aluminum oxide skin allows the excess hydrogen to escape if sufficient time is given for the melt to reach equilibrium.

Prefabricated aluminum houses, in the number of 16,000, have been erected in England since the war. As mentioned by P. Murray, *Light Metal Age,* July 1947, five aircraft companies have built these units, and are fabricating the 38,500 units that are expected to be completed by Spring. The houses arrive at the building site in four sections and can be put in place in two hours. The houses have a floor area of 630 sq ft and contain a living room, two bed rooms, kitchen, bathroom and a hall.

Die-cast aluminum rotors have a number of characteristics that make them superior to the conventional rotor assembled with screws or bolts. As mentioned by J. J. De Windt and G. L. Ringland, *Die Casting,* Sept. 1947, there are no parts to rattle, become detached or shift from their normal position under centrifugal stress. Such a part should run quieter and have a longer life than the present rotors. Another advantage claimed is that the rotor can be permanently balanced. Because of more intimate contact between the die-cast metal and the magnetic iron laminations, there is good heat distribution and little tendency for hot spots to develop. Various operations and tools are omitted by this technique, so that these rotors can be produced quickly.

Molydenum, because of its high melting point, 4,750 F, and other outstanding physical properties, is finding increased usage in the glass and other industries. It is used, as mentioned by J. Celok, *Materials and Methods,* Sept. 1947, for heating elements; blades, nozzles and firing chambers for gas turbines and rockets; dies for die-casting brass; hot-pressing and forming, and hot and cold tools; seamless tubing and valves used in the petroleum industry and as crucibles for melting metals that have lower melting points. Large quantities are used in the glass industry in the form of electrodes to replace carbon electrodes used in electric glass melting furnaces. Molybdenum in combination with tungsten makes possible higher and more uniform temperatures that produce glass of better quality.

IRON AND STEEL

Damping capacity of 12 percent chromium blades in a steam turbine has been found to be halved by 12,000 hours' operation at 300 deg Fahrenheit. L. A. Glickman and M. Z. Grindberg, in the Russian *Journal of Technical Physics,* indicate that none of the other tests applied showed any change. Heating to 1,200-1,250 F and air-cooling restored the original damping capacity. Blades in a similar turbine had been known to fail from fatigue produced by resonant conditions. The authors believe that failure was caused, in this instance, by a sudden loss of damping capacity. The turbine blades had been inspected three weeks before the failure, and at that time evidenced normal damping capacity. Work-hardening of the surface or separation of some intermetallic compound were suggested as possible causes. The authors could find nothing in literature to support these hypotheses and presented them on the basis of observation.

Rupture disk and safety membrane failing stresses can be calculated by formulas presented by R. Bestehorn in *Die Technik.* These formulas do not apply unless the ductility of the material is high, and tensile tests do not correctly evaluate ductility for this purpose. A suggested approach to the design of these units entails actual bursting tests on disks of standard thicknesses. The free surface is progressively reduced, by an annular washer, until the desired bursting point is achieved.

Stainless steel can be joined easily by the arcwelding process if correct techniques are followed. The four general types of stainless require individual treatment to produce the best results. The hardenable ferritic type, 3 to 14 percent Cr, often called martensitic, should be subjected to both preheating and postheating. As mentioned by L. K. Stringham, *Iron Age,* August 28, 1947, preheat temperature of 400 F should be maintained throughout the welding operation. The postheating temperature should be kept between 1,550 and 1,600 F, and during cooling the rate should not exceed 50 deg per hour until 1,200 F is reached. From this point it can be air-cooled to room temperature. Partially hardenable ferritic type stainless steels, 15 to 18 percent Cr, should be heated to 200 F before welding and to 1,450 F after welding. The part should be furnace cooled to 1,000 deg. Fahrenheit. The nonhardenable ferritic stainless steels, above 18 percent Cr, are normally entirely ferritic and are not hardenable by heat-treatment. Joints of this material should not be welded when severe service is anticipated. For light service, the material can be welded with a 25 percent Cr, 20 percent Ni electrode. Conventional heat-treatment will not harden stainless steels of the austenitic type. Little difficulty is found in welding this material because there is no hardening of the weld metal or the heated parent metal. Since it is unstable at elevated temperatures, and since the welding operation takes it through the 800 to 1,200 F range, much care must be exercised to prevent, or to remove, precipitated carbide.

High-speed steel tools have been hardened by a new process that reduces the tendency of irregular sections to crack. Instead of allowing the tools to cool uninterruptedly to room temperature, the cooling is stopped at a temperature of 500 deg Fahrenheit. This point is above the starting temperature for martensite formation. The tool is kept at 500 F for four hours and is then allowed to cool. It is then tempered at 1,050 F for a period of four hours. As the tool is allowed to cool, the four hour hold at 500 F is repeated. The final steps are: Repeat the temper, cool in air, repeat the temper and allow to cool. As mentioned by C. K. Baer and A. E. Nehrenberg, *Iron Age,* September 4 and 18, 1947, this gives the tool no chance to transform to martensite. Transformation to martensite involves a considerable increase in volume at low temperature, while the steel is very stiff and unable to relieve the internal stress accompanying the volume change. The structure produced by tempering the nonmartensite structure (bainite) which is formed on long holding at 500 F seems to be identical with that produced from the conventional martensite. The new hardening process gives a material with cutting power at least equal to the former process; hot hardness and resistance to further tempering are claimed. Cutting power in interrupted cuts is said to be decidedly improved. The longer process proposed would be especially applicable to complicated tools in which quench-cracking losses are high in conventional heat-treatment.

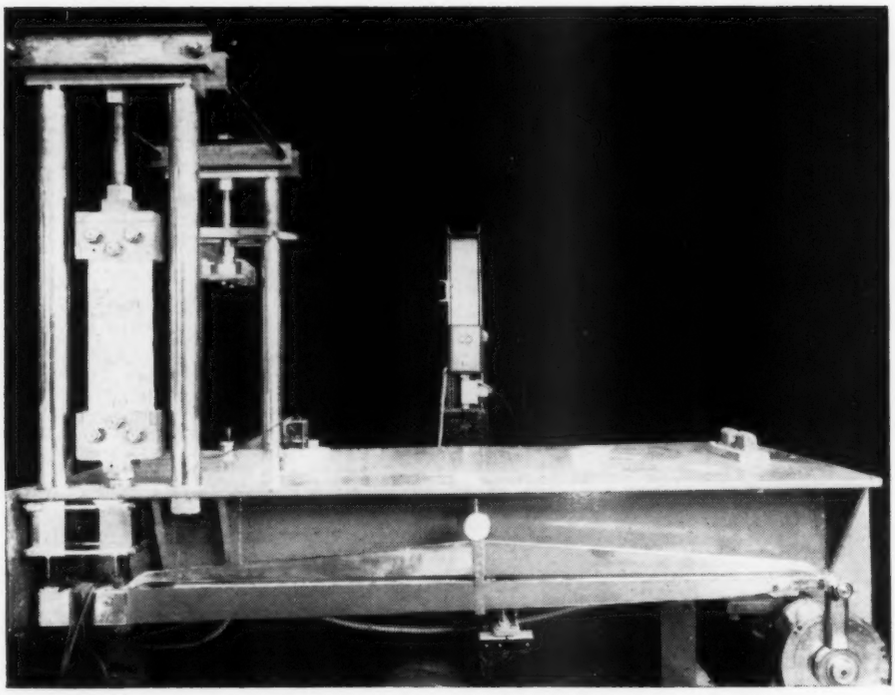


Fig. 1—Spot-welded lap-joint specimen mounted in Krouse testing machine.

(A) Static type of failure in which nugget shears through at the faying plane. Under high stress repeated loading crack propagates from the inner extremity of the Alclad inclusion.

(B) Crack from inner extremity of Alclad inclusion, propagating through weld nugget and parent metal to the outer sheet surface.

(C) Crack starting from faying plane at nugget boundary, skirting nugget boundary and passing through parent metal to the sheet surface.

(D) Crack propagating from stress concentration at corona boundary and passing through the parent metal to the outer sheet surface.

Fig. 2—Characteristic types of fatigue

Spot-Welded Aluminum Lap Joints

Results of a series of fatigue tests of spot-welded lap joints to determine the influence of spot size, sheet thickness, and spot pattern on fatigue strength. Typical radiographs are shown. These specific data are the results of wartime research.

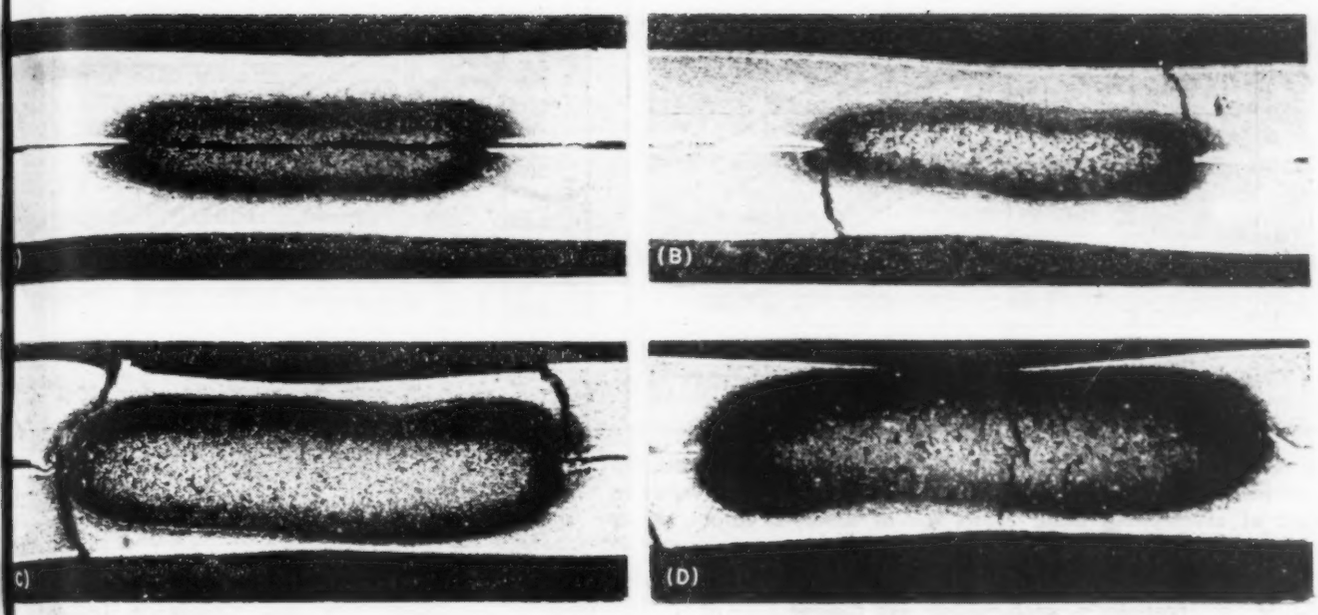
ROBERT C. McMASTER and HORACE J. GROVER
Battelle Memorial Institute

FATIGUE TESTS of spot-welded lap joints of 24S-T Alclad indicate that their strength under repeated tension loading does not increase in the same proportion as their static strength when spot size, sheet thickness, spot spacing, and pattern are varied. Long-life fatigue failures occur by cracking of the sheet around the peripheries of spot welds in contrast to static failures that occur by shearing through the weld nugget. The ratio of fatigue strength to static strength depends on weld nugget diameter, sheet thickness, joint design, maximum repeated stress, and stress range.

A majority of these tests were made on joints spot-welded under conditions representative of good production practice. These specimens were intended to give the effects of variables such as sheet thickness and spot patterns rather than to afford detailed information concerning significant weld properties. The test results afford comparative values of design interest, but do not necessarily give absolute strength values obtainable under all welding conditions. On the other hand, a few tests were made on single-row lap joints with spot welding conditions carefully controlled to produce spots of systematically varied nugget diameter. Spot welds in these specimens were individually radiographed. The results of fatigue tests on these joints afford some information as to the weld properties influencing fatigue strengths. The results also indicate that radiography provides a method of evaluating the fatigue strengths of spot welds in 24S-T Alclad material.

All specimens were subjected to repeated axial loading at 1,200 and 1,500 cycles per min in Krouse testing machines. Load values were corrected for dynamic inertia effect so as to be generally maintained within about $\pm$ 15 lb variation. Some experiments were made at different load ratios, but most of the tests were made at a ratio of minimum to maximum stress of + 0.25. For each load ratio, the corresponding lifetimes in cycles were determined so that the recorded fatigue strength represents the maximum stress withstood by a specimen for a stated lifetime at the designated load ratio.

With high applied loads, which caused short lifetime fatigue failures, the spot welds in single—row lap joint specimens behaved under fatigue loading much as under static loading, the failures occurring by shear of the weld



ilure observed in spot-welded joints of 0.040 in. 24 S-T Alclad aluminum alloy sheets subjected to repeated shear leading.

Designed for Repeated Loads

nugget at the faying plane or by pulling the "weld button" through the sheet. Typical failures are shown in section by Types (*A*), (*B*), and (*C*), Fig. 2. Under low-stress, repeated loading, the long lifetime failures among large spot welds frequently occurred by cracking of the unaffected aluminum sheet. Such failures are shown in section by Type (*D*).

Most of the test pieces were made from 24S-T Alclad aluminum sheet, a material commonly spot-welded in aircraft production. Much of the sheet was 0.040 in. thick, a gage which is also common in aircraft construction. Several lots of the sheet material were required to make the large number of specimens for the various tests. Each lot was tested for static strength properties; sheet from several lots was tested in fatigue. All the materials were up to specifications and of uniform quality.

The data shown in Fig. 3 are representative of the several lots of 24S-T Alclad sheet.

The influence of sheet thickness on both the static and fatigue strengths of single-row spot-welded lap joints is shown in Fig. 4. The effect of joining sheets of unequal thickness is also shown. It is interesting to note the effect on the fatigue strengths produced by running tests at different local ratios, *R*.

Many of the test pieces were cut from 9 by 5 in. sheet with the 9 in. dimension in the direction of rolling. An overlap of 1 in. was used for single-row spot welds, the welds being placed in the center of the overlapping area. The overlaps on double- and triple-row spot welds were 1½ and 2 in., respectively.

Some data illustrating the effect of spot-weld spacing and pattern on the lap joints are given in Fig. 5. Neither

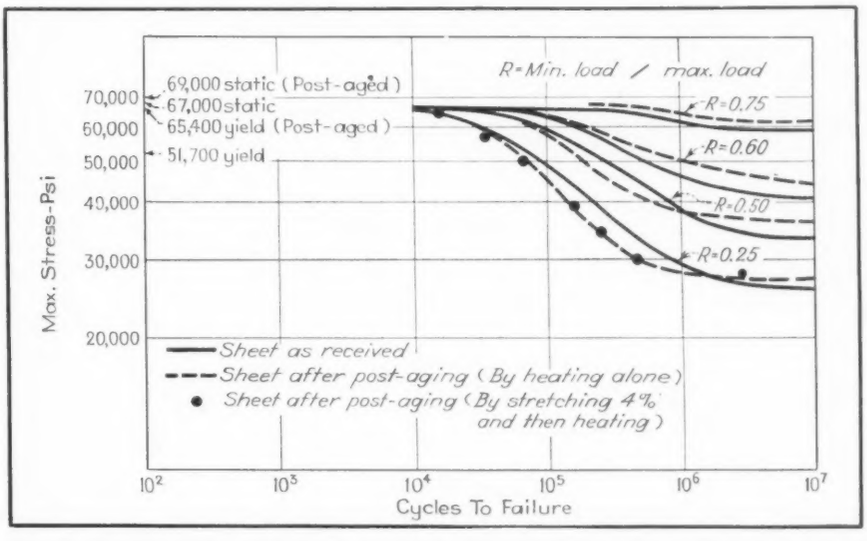


Fig. 3—Fatigue test results of a number of specimens of 24S-T Alclad sheet in the "as received" condition and after post-aging at 370 F for 10 hours.

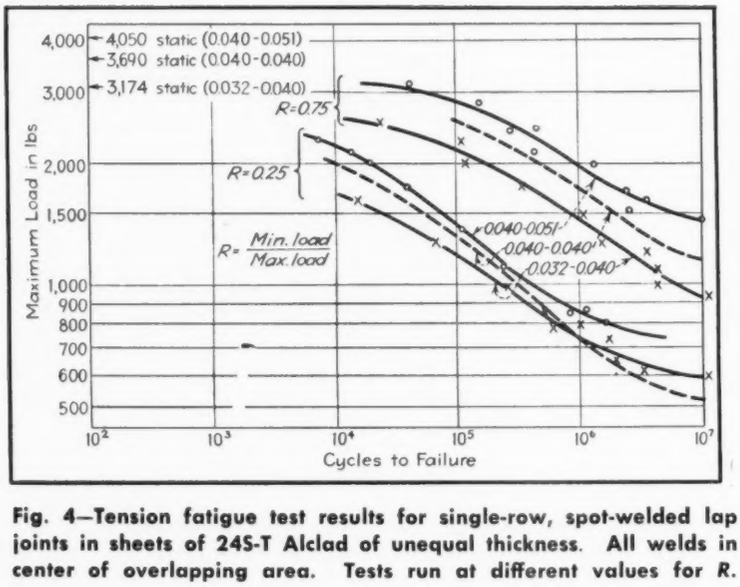


Fig. 4—Tension fatigue test results for single-row, spot-welded lap joints in sheets of 24S-T Alclad of unequal thickness. All welds in center of overlapping area. Tests run at different values for *R*.

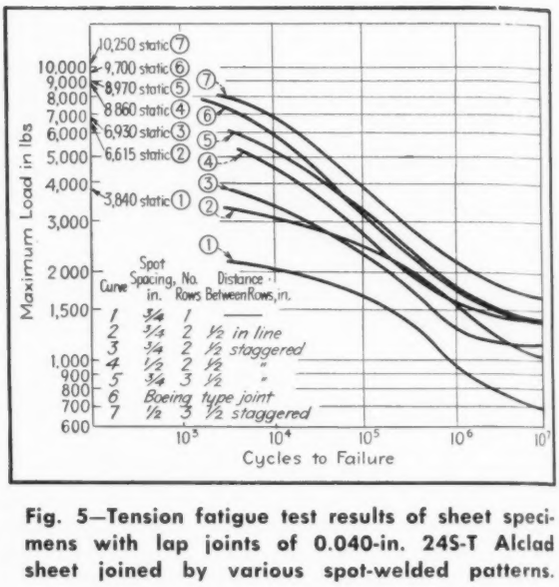


Fig. 5—Tension fatigue test results of sheet specimens with lap joints of 0.040-in. 24S-T Alclad sheet joined by various spot-welded patterns.

post-aging the sheets before spot welding or post-aging spot-welded joints afterward significantly increased the fatigue strength.

It is significant, for design, that an increase in the number of welds in a lap joint has less beneficial effect on the fatigue strength than it has on the static strength.

Welding Procedure

Specimens for the tests described were prepared in different laboratories with slightly different techniques for surface preparation and for welding procedure. (Each group of test pieces for the study of any one variable was prepared under one set of conditions to obtain valid comparisons within a group.) To get some idea of the influence of welding procedure, several additional sets of similar lap joints were prepared by different laboratories. All joints were supposed to be representative of good production practice; no serious welding defects were discovered in any of these samples. All specimens were made of 0.040 in. 24S-T Alclad, with a single row of spot welds spaced ¾ in. apart. Table I gives the static test properties of the material and spot welds. Fatigue test results for a ratio of +0.25 are given in Fig. 6. Note that all the points fall within a reasonably well defined scatter band.

Values for any set show much less deviation from a smooth curve than values for the specimens from several sets. Scatter in static strength is about 35 percent; whereas, scatter in fatigue strength varies from about 21 percent at short lifetimes to about 45 percent at long lifetimes. Scatter is not reduced by plotting ratios of fatigue strength to static strength, for high static strengths do not correspond to high fatigue strengths. These results are regarded as indicative of the variations in fatigue strength to be expected from good commercial practice and may be used for design calculations.

Influence of Spot-Weld Properties

For most of the tests so far described, the dimensions and properties of the spot welds were not recorded

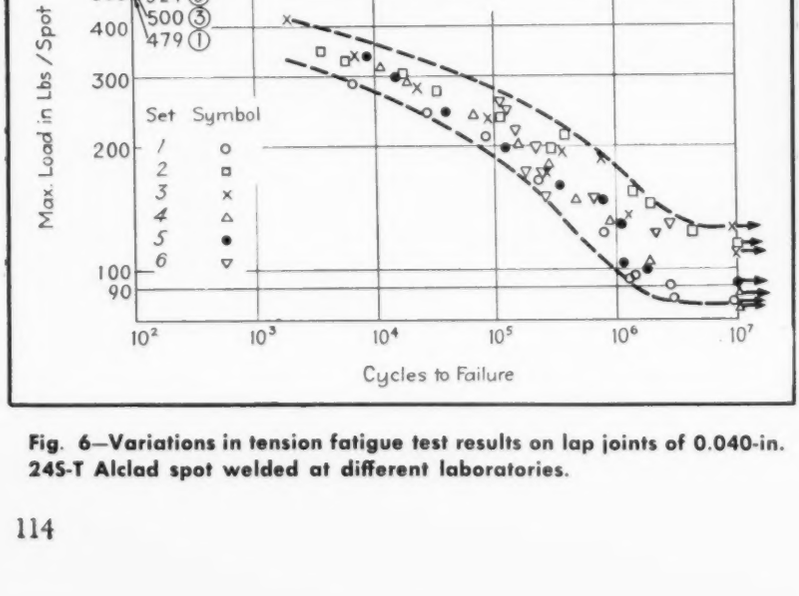


Fig. 6—Variations in tension fatigue test results on lap joints of 0.040-in. 24S-T Alclad spot welded at different laboratories.

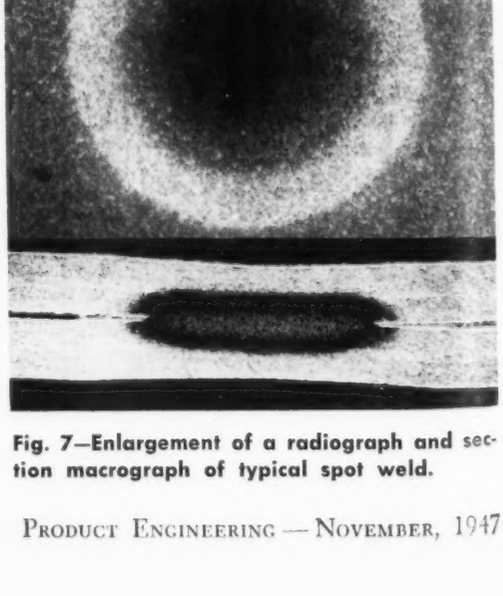


Fig. 7—Enlargement of a radiograph and section macrograph of typical spot weld.

by radiography in advance of testing. The test specimens, made under standard industrial conditions, without the purposeful introduction of defects or of controlled variations in significant weld properties, furnished little fundamental information on the influence of weld defects on fatigue strength. Data that explain clearly what intrinsic weld properties determine the fatigue strength would be of great help in spot-welding design, in the control of welding operations and in the inspection of spot-welded assemblies.

A series of 137 spot-welds in 0.040-in. 24S-T Alclad, welded in a single-row lap joint with several welder current settings, was radiographed prior to fatigue testing, to determine the effect of variations in weld size and properties. These welds, spaced 1 in. apart, were tested in specimens 3 in. wide, each containing 3 welds.

For these single-row lap joints, it was found that the shearing strength of spot welds in either static or fatigue loading can be predicted reliably from radiographic determination of the net area of the cast alloy nugget bonding at the faying plane. This area of nugget bonding is revealed, for aluminum alloys like 24S-T and 75S-T Alclad, by the inner boundary of the prominent dark ring on the radiographs. Fig. 7 shows an enlargement of a radiograph and a micrograph of a typical spot weld after fatigue testing. Fig. 8 indicates the welding energy, as well as the results of the fatigue tests, associated with the wide range of nugget sizes.

If the fatigue strengths of the spot welds are charted with respect to the area inclosed within the inner boundary of the radiographic dark ring, the curves of Fig. 9 are obtained. Note the greater rate of increase in static strength with larger nugget size in comparison with the rate of increase in fatigue strengths, at different lifetimes, with the corresponding increase in nugget size.

Weld Nugget Size

These data imply that, in spot-weld design of lap joints for high stress repeated loading, there is no advantage in restricting the nugget diameter or the static shear strengths to low values. Both static and high stress fatigue strengths will be improved by increasing the weld nugget size, and the low stress fatigue life will not be lowered.

Curves of the type shown in Fig. 9, particularly if based upon more comprehensive test data than presented here, could be used in the design of spot-welded joints for fatigue service, just as similar curves are now used to establish designs for static loading. Specifications for welding and inspection standards might be established for parts subjected to repeated loading and might, in general, be different from those used for parts subjected to static loading alone.

Note from Fig. 9 that the load for shear failure does not approach zero as the weld nugget area decreases. Instead, the curves for all lifetimes

Table I—Properties of Spot Welds* Produced at Different Laboratories

Set No.	Ultimate Strength of 24S-T Sheet, Psi	Yields Strength of 24S-T Sheet, Psi	Elongation in 2 in., Percent	Avg Dia of Spot Welds, in	Penetration into Each Sheet, percent	Static Strength of Spot Welds, lb per spot
1	64,300	48,800	19	0.185	77	479 ± 10
2	66,000	47,300	19	0.200	47	635 ± 40
3	65,350	43,950	18	0.175	41	500 ± 40
4	64,750	51,300	16	0.230	65	615 ± 2
5	68,500	54,700	19	0.175	58	520 ± 7
6	67,000	52,500	17	0.215	38	595 ± 5

*All sheet material 0.040-in. thick, cut in the direction of rolling. Each lap joint had 6 spot welds in center of 1-in. overlap, spaced ¾ in. apart.

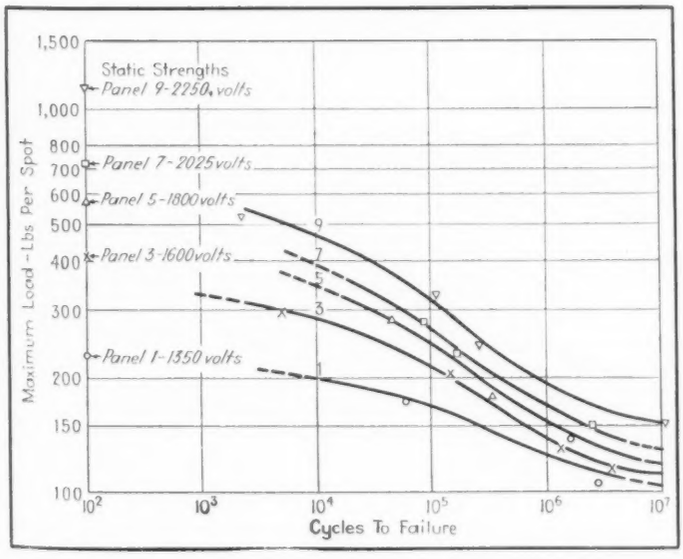


Fig. 8—Stress-cycle (S-N) curves for single-row lap joints in 0.040-in. 24S-T Alclad for weld enegy varied over a wide range.

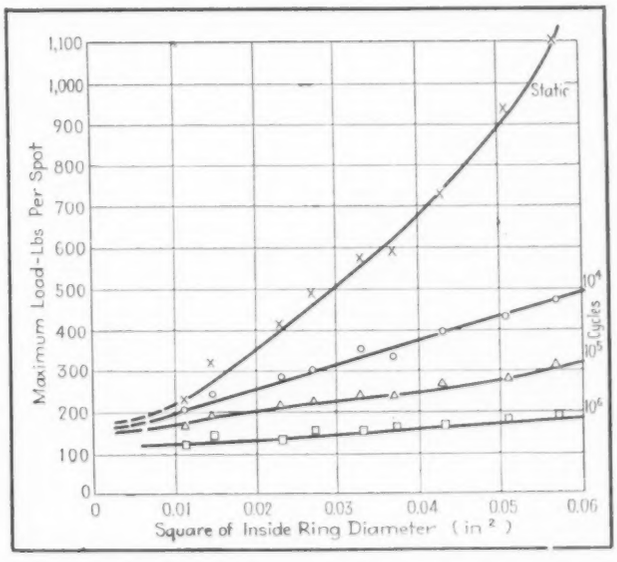


Fig. 9—Correlation between maximum load for shear failure and area within the dark ring of a spot weld.

appear to approach a common point, near 125 lb shear strength for these weld specimens, when the nugget diameter is zero. This strength is attributed to the Alclad bonding at the interface, normally present in the corona region of a spot weld. Spot welds, in which the nugget has not broken through the Alclad layers at the interface, can be made with areas of corona or Alclad bonding large enough to pass static shear strength acceptance tests without difficulty. The shear strength of Alclad bonding may be as high as 10,000 lb per sq in. in spot welds of 0.040-in. 24S-T Alclad alloy. By comparison, shear strength of the cast alloy nugget is near 20,000 lb per sq in., while the shear strength of the unaffected parent material is above 40,000 lb per sq inch. Spot welds can be made in which the corona bonding provides little or no strength, particularly if the welds are made in sheets with dirty or oxidized faying surfaces.

The Alclad bonding may contribute to the fatigue strength of spot welds, as well as to the static shear strength. The high-stress, short-lifetime fatigue strengths correlate well with the nugget area at the faying plane. It is probable that in these fatigue tests, just as in static tests, the corona bond tended to fail before the nugget failed, so that the ultimate failure was a function primarily of nugget size and strength. At low fatigue stresses, as already indicated, the fatigue strengths show almost no correlation with nugget diameter.

Low stress failures occurred as cracks propagating through the sheet with no evidence of failure of either the corona bond or the nugget at the faying plane, Type (*D*), Fig. 2. For this reason, it appears probable that the fatigue performance of large spot welds under low repeated stress is primarily a function of the circumference of the well-bonded corona region.

Radiography provides a nondestructive measure of the diameter of spot-weld nuggets in 24S-T Alclad, and is a sensitive indicator of weld cracking and other defects. It provides a method of evaluating the weld properties that influence the fatigue strength of spot welds. No other test, destructive or nondestructive, is regarded as provided so clear an indication of these properties.

German Powder Metallurgy Report

HIGHLY INTRICATE DIES employing a number of independents punches fitted in a die sub-press were used by the Germans in pressing rifle and gun parts from powdered metals, according to a British report on German power metallurgy issued by the Office of Technical Services, Department of Commerce. The entire assembly was designed for use in a standard type of hydraulic press with top and bottom rams which eliminated the need for complicated presses with multiple die movements. Iron powders were also used for porous iron bushings, bearings, sliding parts, gears, bullet slugs, precision parts for rifles and diamond impregnated iron lapping wheels.

The report was made by an industrial intelligence team of the British Intelligence Objectives Sub-Committee and is based on visits to 10 German plants. A second report on iron powder metallurgy, made by J. C. Richards of the Australian Scientific and Technical Mission, is also available from OTS. This report gives notes on German production methods at two additional plants.

Copper and iron powders were given most attention since these two metal powders from the most important constituents by volume and weight employed in powder metallurgy today. Because of shortages of raw material, the investigators found that Germany was unable to produce any important amounts of copper powder during the war and iron powders were substituted. Production of iron powders rose from 200 tons in 1938 to 32,000 tons in 1944. The Germans claimed that the manufacture of shell driving bands consumed 1,000 tons of iron powder alone per month during 1943-44.

Although electrolytic deposition, atomization, and reduction processes were used, the bulk of German iron powder manufacture was by the "Hematag" mechanical crushing process. In 1944 about 75 percent of the total production was by the "Hematog" process. The only improvements over American and British practices noted by the investigators were in sintering furnaces. There were, however, unique improvements in specific plants which were not industry-wide.

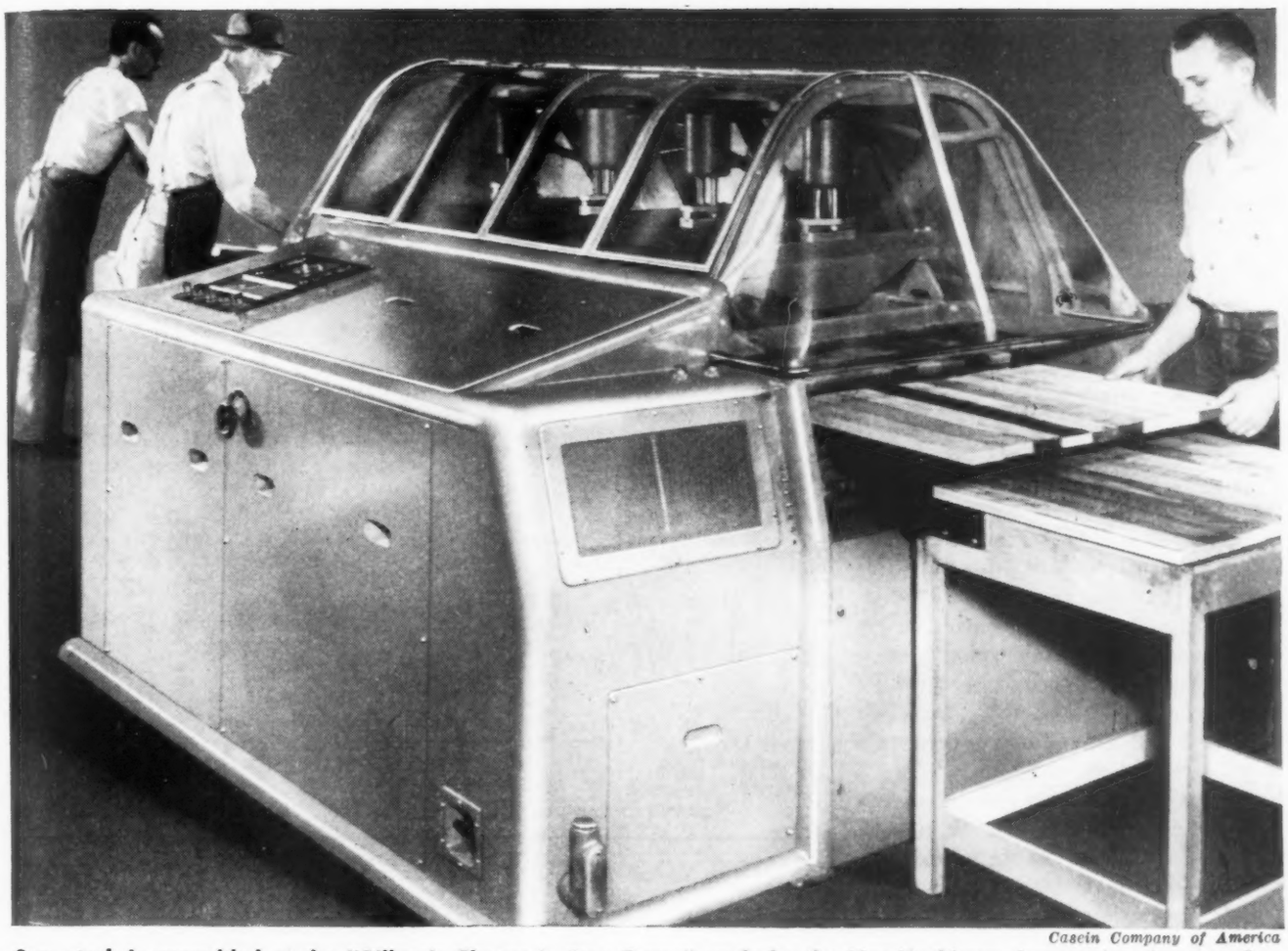
At the Vereingte Deutsche Metallwerke, A. G., at Neurod, the team investigated two types of sintering furnaces made by Elino of Kresbsoge, Rhineland, and Siebert of Hanau. The Elino furnaces are straight through tunnel furnaces, the work being packed into boxes and loaded into an end compartment and removed in a similar way at the other end or simply pushed into an open end and conveyed through without a charging compartment.

The Siebert furnaces are of the tilting type with a central heating section 8 ft long with top and bottom heating elements of molybdenum. The cooling zone is 4 ft long and water jacketed. The loading arrangement consists of a cam working from an external wheel which engages with the back of the box and pushes it into the heating zone. The tilting of the furnace on the larger rocker permits the boxes to slide down towards the discharge end by gravity.

The atmosphere in both types of furnaces is hydrogen or charcoal gas. The work is sintered in graphite boxes with a layer of aluminum oxide on the bottom and further layers between each layer of pressings to prevent welding of the compacts and absorption of graphite by iron.

In addition to giving the information on all methods used at the plants, the reports contain photographs, microphotographs, drawings, and tables.

Orders for the reports, PB-63874, (microfilm, $4; photostat, $11) and PB-63610, (microfilm, $1; photostat $2) should be sent to the Office of Technical Services, Department of Commerce, Washington 25, D. C., accompanied by check payable to the Treasurer of the United States.



Casein Company of America

Core stock is assembled at the "Gillespie Electronic Core Press," made by the Pico Machinery Corporation, Los Angeles, Calif. Machine sets the adhesive with radio frequency heating, and applies vertical and lateral pressure to the assembly.

INDUSTRIAL ADHESIVES—I

NICHOLAS J. DE LOLLIS
National Bureau of Standards

First of a two-part series, covering vegetable, protein and thermoplastic resin types of industrial adhesives. Effects on bond strength of preparatory surface treatments, modulus of elasticity, coefficient of expansion, and new techniques such as high frequency heating.

IN ADDITION to conventional animal and vegetable adhesives, many new synthetic resin adhesives have been developed for specific industrial applications.

Animal and vegetable glues, which are relatively weak, are still widely used because they are low in cost. Vegetable adhesives are used mainly with paper, a weak material, which does not require a glue with strong cohesion. Even in this application, when a water soluble glue with fungi resistant properties is desired, price becomes secondary and a synthetic resin, polyvinyl alcohol, is used. The inherent weaknesses of animal glues have limited their use to wood and paper, but only where there is minimum exposure to weathering. Extreme dryness or extreme moisture tend to deteriorate these glues.

The synthetic resins are constantly expanding into new fields. Urea and phenolic glues are used on the more durable plywood and wood construction jobs. The polyvinyl adhesives constitute the most versatile group; their greatest use is in the manufacture of safety glass. The unsaturated polyester resins are important in the manufacture of glass cloth laminates.

Since the strength of the material to be bonded is probably the most important consideration in its selection for structural purposes, the bonding strength of the adhesive used with it should be of comparable magnitude. Thus, the required strength of an

adhesive bond is a relative matter, not dependent only on service conditions.

Gum arabic, which attains a shear strength of about 500 lbs/in² with wood, is more than strong enough for most paper applications. Most commonly-used paper glues such as starch and dextrin, form bonds which are stronger than the paper. However, their adhesive and cohesive strengths are rather low for wood and metals. For wood and similar fibrous materials, casein, phenolic, urea and melamine adhesives are sufficiently strong. The adhesives used with wood usually have shear strengths varying from 1,000 to 2,000 psi. Special adhesives have been developed for use with metals. These have shear strengths averaging around 4,000 psi and are known as phenolic elastomers.

Rubber adhesives are comparatively weak but have shock absorbing properties which make them more useful for certain applications than stronger adhesives. Rubber adhesives bond to a wide variety of materials. When vulcanized they average around psi in shear strength. The average shear strengths are about 50 psi when applied as solvent-release adhesives.

Thermoplastic adhesives will bond to many different materials, but since they have a tendency to flow they are not suited for structural loads. For short duration shear bonds, however, polyvinyl acetate averages 3,500 psi for metals, 2,300 psi for glass, and 1,400 psi for wood.

Durability of Glues

Resistance to	Casein without preservative	Casein with preservative	Urea Resin cold press (AN-G-8)	Urea Resin fortified hot press	Phenolic, Phenolic Type hot or cold press (non-acid)
Indoor Conditions 65 percent relative humidity and 80 F. (continuous)	Excellent	Excellent	Excellent	Excellent	Excellent
Water-soaking at room temp. (continuous)	Poor	Poor	Good	Good	Excellent
Moisture (and Mold) 97 percent relative humidity and 80 F. (contonuous)	Poor	Fair	Fair	Good	Excellent
Dry Heat 20 percent relative humidity and 160 F. (continuous)	Excellent	Excellent	Fair	Good	Excellent
Heat and Moisture 60 percent relative humidity and 160 F. (continuous)	Good	Good	Poor	Fair	Excellent
Outdoor Conditions (plywood panels and laminated beams)	Poor	Fair	Fair	Fair	Excellent
Ability to Bond (sawed surfaces at low pressure)	Good	Good	Fair	Fair	Excellent

Matching Properties

The phenolic adhesives have a high modulus of elesticity. When used to bond metals or glass, which also have high moduli of elasticity but different coefficients of thermal expansion, they have little or no adhesion. When a high modulus adhesive is bonded to a high modulus material, a difference in the coefficient of thermal expansion can cause sufficient stress at the interface to rupture the bond after the adhesive has cured to its solid state. They bond wood and similar cellulosic materials of medium or low modulus of elesticity extremely well. When the phenolics are modified by the addition of rubbery compounds to form the phenolic elastomers, strong bonds are made to metals and to practically any material which can withstand the necessary pressures and temperatures required to make the bond. This modification lowers the modulus of elasticity, so that there is enough elastic flow to compensate for differences in coefficients of thermal expansion.

When used to join materials that have widely different thermal expansion coefficients thermoplastic adhesives such as polyvinyl acetate have sufficient plastic flow even at room temperatures to prevent the establishment of high stresses under wide changes of temperature that cause differences in expansion. These adhesives can therefore be used to bond a wide variety of materials, for which they are noted.

However, when the temperature is lowered to the point where the adhesive hardens and loses much of its plasticity, its adhesive properties are greatly impaired.

Investigations carried out at the National Bureau of Standards by P. S. Turner have shown that the coefficients of thermal expansion of components can be matched, thereby giving a bond which is not subjected to stresses caused by changes in temperatures. The following formula was developed by P. S. Turner to indicate the volume thermal coefficient of a mixture:

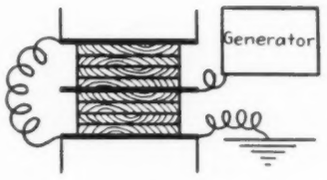
$$\alpha_r = \frac{\frac{\alpha_1 P_1 K_1}{d_1} + \frac{\alpha_2 P_2 K_2}{d_2} + \ldots + \frac{\alpha_n K_n P_n}{d_n}}{\frac{P_1 K_1}{d_1} + \frac{P_2 K_2}{d_2} + \ldots + \frac{P_n K_n}{d_n}}$$

α = coefficient of linear thermal expansion
r = resultant mixture
K = bulk modulus
P = fraction or percent by weight
d = density
1, 2 and s = different constituents

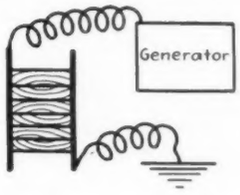
A factor of primary importance in the formation of a strong adhesive bond is surface cleanliness. Dust, grease and loose oxide films are constant dangers to adhesive bonds and on different materials specific cleaning techniques are required.

Wood absorbs oils, greases, and dust from the air, especially where heavy industry predominates. To eliminate them, wood should be lightly sanded just before glue is applied. Sanding is used primarily to produce a clean, fresh surface, and is not intended to roughen the surface. A rough surface reduces the area of close contact and results in an uneven glue line. This increases the chances for voids, flaws and starved joints. Crazing occurs more readily in a thick glue line. A fine glue line with close contact be-

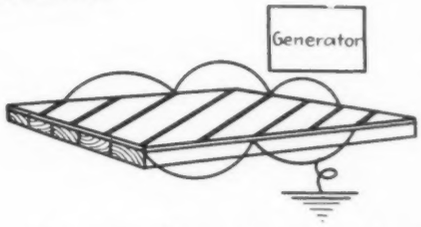
High Frequency Heating of Glued Assemblies



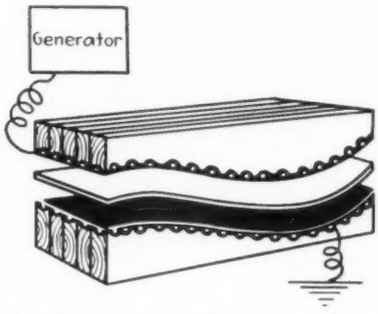
"Perpendicular" heating of two matched assemblies in grounded press. Flow of energy is perpendicular to the glue line.



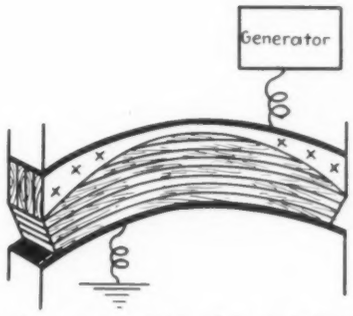
"Parallel" heating of a laminated construction with electrodes in direct contact with the glue line, where heat is concentrated.



"Stray-field" bonding. For "tacking" strip areas of plywood to a solid lumber core or to wood framework for prefabricated sections.



"Perpendicular" heating of curved assembly. Note the rounded edges of the metal. High frequency energy tends to discharge off any sharp points on electrodes and transmission lines.



"Perpendicular heating of a construction of irregular depth showing how a wood "dummy" block (X) can be used to keep electrodes parallel for uniform heating of the entire construction.

Casein Company of America

tween the adhering surfaces is the best guarantee of a strong bond. This is true for any combination of materials.

Metallic materials, as received from the fabricator, are usually covered with films of grease, oil, and oxide. Grease and oil are removed by organic solvents, usually chlorinated hydrocarbons.

If the oxide film is a hard, impermeable one, as in anodized aluminum, the adhesive can be used directly on the oxide surfaces. Usually, however, oxides are removed by pickling in acid baths. Ordinary iron and steel can be cleaned in hydrochloric acid; stainless steels sometimes require the more rigorous mixture of dilute aqua regia. Brass and copper can be cleaned in chromic acid, but care must be taken that the surfaces are completely cleaned of adsorbed chromic acid. Aluminum surfaces can be treated in a dilute (5 percent) phosphoric acid solution. Long immersion in acid will pit the surface.

Glass easily picks up a film of oil or grease. Heat will drive off the surface film of organic matter, or solvents, such as acetone or benzene, will dissolve it. Alkaline solutions of trisodium phosphate or a heated sulfuric acid solution of sodium dichromate can also be used.

Phenolic laminates and impregnates have a passive surface layer, believed to consist of highly polymerized phenolic resin, to which adhesion is difficult. This surface should be removed by sanding before the adhesive is applied. Other thermosetting plastics receive the same treatment.

A thermoplastic material can usually be cleaned in one of its own solvents, especially since by combining with the solvent it forms its own adhesive. The usual method is to soak the surface until it has absorbed some of the solvent; then the thermoplastic surfaces are joined, so that they fuse together. The solvent should be neither too powerful nor too volatile or crazing of the bond will result when the solvent evaporates. Evaporation of the solvent, with or without application of heat, helps obtain maximum bond strength.

Radio Frequency Heating

The use of radio frequency heatitng for curing glue joints offers the following advantages: (1) It produces rapid and relatively uniform heat; (2) with "parallel heating", it produces this heat in the glue line without an appreciable loss of moisture in the stock, eliminating the necessity of reconditioning the wood; (3) it can be used to heat curved assemblies where the cost of complicated, steam heated forms might be prohibitive. Forms for radio frequency may be made of wood or other workable material covered with only a thin metal electrode; (4) radio frequency power can be used to quickly heat the deep glue lines in heavy constructions such as laminated timbers which would require hours of heating by ordinary hot-plate or hot-air methods.

When used with room-temperature-setting glues, radio frequency energy may be economically concentrated to "tack" small areas of the joint, sufficient to maintain pressure, allowing the remainder of the glue line to cure in warm storage or at room temperature.

The chief disadvantage of a radio-frequency heating method is the relatively high cost of both the equipment and the power used. Even though the method is efficient in the sense that it heats only the material between the electrodes, it is not an economical

Casein Company of America

Wood sheaves for V-belt drives are made by Dodge Manufacturing Corporation. Laminated from straight-grain, kiln-dried, hard maple, with powdered casein glue, this product illustrates the superior strength obtainable from laminated constructions.

Bakelite Corporation

Aluminum sheets bonded with vinyl adhesive. Shear of joint is greater than 4,500 psi of overlap—twice that of conventional aircraft riveted joints. Such joints have withstood a static load of 2,500 psi of overlap for 10 hr.

source of heat when compared, for example, to steam or hot air. For this reason, the method is seldom used for extremely large heating operations.

Types of Adhesives

VEGETABLE TYPE. The simplest adhesives in common use are those of vegetable origin, including starches, dextrin, tapioca, and natural gums such as gum arabic. Flour paste is a low cost gluten-starch combination with good adhesive strength. Because of its slow drying rate and low viscosity, it is applied by hand or by simple machines.

Starch pastes, most extensively used in automatic packaging machines, spread easily and dry rapidly. Acid or alkali modifiers are used to make such pastes thick and tacky. Alkaline starch, useful in penetrating the sizing on some papers, gives a tough continuous film, and acid converted starch dries to a crystalline brittle film. Starch pastes are cheaper and easier to handle than animal glues; thus, they are important in plywood manufacture, when the plywood is not required to meet rigid tensile strength or water resistance specifications.

Dextrin adhesives are expensive compared to starches, but have the advantage of being especially fast-setting and tacky. They are in great demand for the faster machine packaging operations.

Gum arabic is the most useful water soluble natural resin adhesive. Used in high concentrations, it is superior to even the dextrins in difficult packaging operations, despite its higher cost. It is specified for packaging exposed to tropical conditions and where light color is an advantage.

PROTEIN TYPE. Protein glues hvae higher joint strength and moisture resistance than the vegetable glues. The most common type is animal glue, produced from hide or bone. It is used mainly in the woodworking trades and applied manually. Because it tends to become stringy, protein type glue is not applied by hugh speed machines. Fish glues are similar but are not used as widely because of their high cost and bad odor.

Blood and egg albumen glues are useful because they become insoluble when heated. Their chief use is in the making of plywood, and, next to synthetic resin thermosetting glues, they were the most durable and water resistant glues.

Casein, made from milk curd, has long been used to form strong waterproof wood joints and to make a durable plywood. It is a good glue for surfaces which do not make close contacts, since it has high strength even in thick glue lines. It is a cold press glue and can be used at lower temperatures than other glues. Although it does resist the action of water for short periods, casein is unsuitable for prolonged exposure to the elements or for marine equipment.

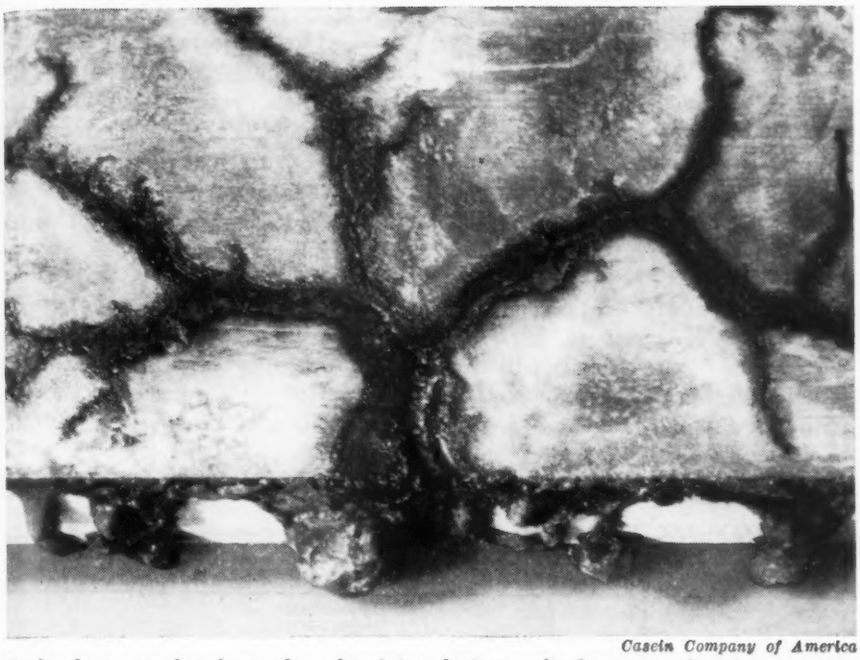
Soybean protein glue has recently found wide use in the manufacture of plywood. Although it lacks tackiness, it is the cheapest water-resistant glue. Most wood veneers should have 5 percent or less moisture content for gluing purposes, but soybean protein glue will tolerate as much as 15 percent moisture content and can therefore be used with greener veneers.

Synthetic Resin Adhesives

Synthetic resin adhesives differ from vegetable and animal glues in their increased bond strength, almost complete resistance to moisture, various molds and fungi.

THERMOPLASTICS. The thermoplastic adhesives are important for their versatile adhesive properties and their clarity. They differ from the thermosetting resins in their increased flow characteristics with temperature rise.

Thermoplastic resins are soluble in



Casein Company of America

Path of an arc that burned a glue joint during radio-frequency heating. Arc is caused by a conductive glue that "short circuits" power in glue line. Instantaneous charring occurs, leaving a carbon track, and preventing cure of the rest of the glue line. New "non-arcing" phenol-type resin glues are now available.

many different solvents, and soften to a point of fusion when heated. Both of these properties are utilized when formulating adhesives. The "solvent-release" type of adhesive is applied in solution form, allowed to get sufficiently tacky to hold the contact surfaces, and completely dried with or without the application of heat after the surfaces are joined. This gives a joint sufficiently strong for paper, cloth, and other thin, flexible sheet materials.

For stronger, more rigid materials such as glass and metals, solvent release adhesives cause faulty glue lines because of shrinkage from loss of solvent. The strongest bonds result when the surfaces to be joined are coated with a solution of the adhesives. These surfaces are thoroughly dried before being joined; heat and pressure are then applied until the fusion point is reached. Sufficient pressure is used to assure a thin glue line of about 0.002 in. in thickness. This pressure must be maintained until it is cooled to room temperature.

Cellulose nitrate is used to cement glass, metals, leather, cloth and ceramics. In making safety glass, it was discarded in favor of the polyvinyl resins since it became discolored on prolonged exposure to sunlight. Because of its flammable nature, it is also difficult to handle without special care.

Cellulose acetate has uses similar to the nitrate and is superior to it in aging properties and fire resistance. It is inferior, however, in adhesion and moisture resistance, and slightly more expensive. Cellulose acetate butyrate is more durable and moisture resistant than the acetate. Ethyl cellulose cements are used for bonding cloth, paper and metal foil. They are more resistant to chemicals than most of the other cellulose derivatives.

Methyl cellulose is equally resistant to chemical action. This, together with its water soluble properties, allows it to replace vegetable glues where a sterile cement is required.

The methacrylates and acrylates are not quite as soluble as the cellulose compounds, and have better aging properties, since they do not require plasticizers. Their properties are modified either by varying the degree of polymerization or by copolymerizing with other methacrylates or acrylates. Both the methacrylates and acrylates bond a wide variety of materials. The methacrylates are tougher than the acrylates and have much higher softening points. They have water clear transparency and good weathering properties. The acrylates are pliable and tough, and are important because of their permanent tack, which can be varied widely. They adhere well to smooth non-porous materials, such as metals and glass.

The styrene resin adhesives, noted for their high dielectric strength and resistance to water absorption, are excellent in electrical installations.

The vinyls are the most versatile of the synthetic adhesives. They are tough and clear and form good bonds to practically any material, porous or non-porous. Polyvinyl alcohol, soluble in water at 70 C, resists the action of fats and many organic solvents and is stable and impermeable to gases. These properties make it useful as a primary glue for packaging in the food industry, and as a blending agent for improving the performance of vegetable glues, such as starches.

Vinyl acetate adhesives are used for a wide variety of materials, especially thermosetting plastics, metals and glass. Its heat-sealing properties are important in the packaging industry, where non-fibrous films such as cellophane are used. Its moisture resistance is satisfactory for most purposes. Polyvinyl acetate, which resists discoloration from aging and has about the same refractive index as glass, forms a strong elastic bond to glass.

Although polyvinyl chloride has excellent moisture resistance, it gives a hard, brittle film and less adhesive action than the acetate. It has good electrical properties and high chemical resistance. Plasticizers that modify its brittleness must be used with moderation since they usually impair the adhesive properties. In polyvinyl chloride-acetate, advantage is taken of the moisture and chemical resistance of the chloride and of the elastic toughness of the acetate.

Bonding with vinyls is accomplished by either of two methods: Cold set and hot set. Cold setting, because of the adhesive's strong initial tack, permits the fabrication of articles quickly and economically before the solvents have evaporated. However, it requires a longer period of time to reach ultimate bond strength; actually, the time necessary to dispel the solvent. Also, it is not readily adaptable to the bonding of non-porous surfaces which tend to trap the solvent or retard its evaporation. For hot-setting, the adhesive film is baked for a few minutes at 225 to 250 F, to assure complete release of the solvent,

or water when emulsified adhesive is used. When adhesive is applied as a hotmelt, drying is unnecessary—the treated surfaces can be bonded immediately or stored for bonding at a later date. The actual bonding can be achieved quickly by the application of heat and pressure.

The polyvinyl acetals are the latest additions to the vinyl family. They are tougher and more resistant to water but less resistant to weathering than the corresponding acetates. The best known of these is polyvinyl butyral, used as the interlayer in safety glass. In this application it has offered such excellent adhesion that edge-shrinkage is eliminated. Also, because of its low water absorption, it does not turn hazy, and therefore obviates edge sealing. It is ten times more resistant to rupture at 10 F, and four times more resistant at 70 F than equivalent thicknesses of interlayer materials previously used. Other uses of vinyl butyral adhesives are: Bonds for tough, flexible sheets of mica, and components in plywood adhesives. The powders are usually compounded with other types of resins to produce general-purpose adhesives.

Vinyl resins form strong bonds as measured by static strength tests. Where steadily increasing loads are applied, however, their thermoplastic flow properties make them useful in non-structural uses only. This is true, in varying degrees, for all thermoplastic adhesives.

EDITOR'S NOTE: Part II of this article covering thermosetting and rubber adhesives, as well as applications of all adhesives, will appear in the December issue of Product Engineering.

ADHESIVES MANUFACTURERS AND PRODUCTS

MANUFACTURER	TRADE NAMES	COMPOSITION
American Cyanamid Co.	Urac 100, 185	Urea Formaldehyde
	Melmac 400	Melamine Formaldehyde
	Melurac 300	Melamine Urea Formaldehyde
	Phenac	Phenol Formaldehyde
	Laminac P 4122	Unsaturated Polyester
Arabol Manufacturing Co.	Arabol	Gum Arabic
B. B. Chemical Co.	Bostick Cement E-22-1	Vinyl resins and rubber
	Bostick Cement 292	
	Bostick Cement M99	
Bakelite Corp.	BC-16168	Phenolic resin, hot set
	BC-17540	Phenolic resin, medium set
	XC-17613	Resorcinol resin, cold set
	BRS-16631	Unsaturated Polyester
Carbide & Carbon Chem. Corp.	T24-9 and MA28-18	Polyvinyl Acetate solution
	Series A	Polyvinyl Acetate
	Series V	Co-polymer Vinyl Acetate and Chloride
	Series Q	Polyvinyl Chloride
	Series X	Polyvinyl Aldehydes
Casein Company of America	Cascophen Series	Phenol Formaldehyde
	Cascamite Series	Urea Formaldehyde
	Casco Series	Casein
	Cascophen 216	Resorcinol Formaldehyde
Catalin Corp.		Phenol Formaldehyde
Columbia Chemical Div., Pittsburgh Plate Glass Co.	Allymer CR-39	Allyl resin
	Allymer CR-149	Allyl resin
	Allymer CR-170	Allyl resin
Cordo Chemical Corp.	Cordo Bond 70	Vinyl resin
	Cordo Bond 200	Vinyl resins
Cycleweld Div., Chrysler Corp.	Cycleweld C-3	Synthetic Rubber and Phenolic resin
	Cycleweld C-55-9	Synthetic Rubber and Phenolic resin
Central Process Corp.	Everlite 4258	Plasticized Phenolic resin
	Superbond	Phenolic resin
Compo Shoe Machinery	Adhesive 5871	Nitrile Rubber and Phenolic resin
Dow Chemical Co.	Ethocel	Ethyl Cellulose
	Styron	Polystyrene
E. I. du Pont de Nemours & Co.	Fairprene	Neoprene base
	Polythene	Polyethylene
	Lucite	Methyl Methacrylate
	Butacite 4644	Polyvinyl Butyral
	Pyroxalin 5458	Cellulose Nitrate
	Pasticele	Cellulose Acetate
	Adhesive 4646	Vinyl, thermoplastic
	Adhesive 4624	Vinyl, thermosetting
Durez Plastics & Chemicals, Inc.	Durez 196	Phenol Formaldehyde—high temperature
	Durez 12041	Phenol Formaldehyde—med. temperature
	Durez 12689	Phenol Formaldehyde
	Durez 13793	Phenol Formaldehyde—room temperature
	Durez 12987	Phenol Formaldehyde

MANUFACTURER	TRADE NAMES	COMPOSITION
Durite Plastics, Inc.	Durite S 3026	Resorcinol resins
	Durite S 3024	Resorcinol resins
	Durite S 2982	Resorcinol resins
	Durite S 2984	Resorcinol resins
B. F. Goodrich Co.	Plastilock 500,101	Synthetic organic resin
	Vulcalock	Synthetic organic resin
	A-68B; A-75B	Synthetic rubber
	Plastikon 161, 169	Reclaimed rubber
	Adhesive 4, C-82-S	Pure gum rubber
Goodyear Tire & Rubber Co.	Pliobond	Thermoplastic resin
Hercules Powder Co.	CMC (Cellulose Gum)	Sodium Carboxymethylcellulose
	Parlon	Chlorinated rubber
	Pentalyn, Staybelite, Hercolyn	Rosin esters
	Cellulosic resins for conversion to adhesives.	
Miracle Adhesives, Inc.	Miracle Adhesive, Type P	Rubber
	Miracle Adhesive, Type R	Rubber
	Miracle Adhesives Type H-M and MT	Rubber
National Adhesives Div., National Starch Products, Inc.	Wood-lok	Synthetic resin
	Multi-lok	Synthetic rubber
	Vulca 100, 60, 30	Starch
	Resyn	Synthetic resins
Naugatauk Chemical Div., U. S. Rubber Co.	Adhesive 355	Rubber base and accelerator
Pennsylvania Coal Products, Inc.	Penacolite G1131	Resorcinol Formaldehyde and separate curing agent
Perkins Glue Co.	L-100, D-111, DC-246	Urea Formaldehyde
	N-411	Melamine-Urea resin
	Adhesive 183, 300-C	Vegetable glues
	Coldide glue	Animal glue
	Sunrise, Aircraft Joint	Casein glues
Plaskon Div., Libby-Owens-Ford Glass Co.	Plaskon, 900-911-920	Unsaturated Polyesters
	Adhesive 107, 250-2, 201	Urea Formaldehyde
Furane Plastics & Chemicals Co.	Resin X-2	Furan derivative
Resinous Products & Chemical Co.	Tego Film and Tape	Phenol Formaldehyde
	Amberlite PR-245, Pr-14	Phenol Formaldehyde
	Uformite	Urea Formaldehyde
	Redux	Phenolic and Polyvinyl resins
	Paraplex P-10, AP-43	Unsaturated Polyesterse
	Amberlite PR 115	Resorcinol Formaldehyd
Swift & Co.	R Series	Rubber base cements
	Adhesive 1197S	Synthetic resin
	Adhesive 103S	Resin and protein
U. S. Plywood Corp.	Weldwood	Urea Formaldehyde
U. S. Stoneware Co.	Tygon F 460	Furane derivative
	Reanite	Furane derivative
Westinghouse Electric Corp.		Resorcinol Formaldehyde
Williamson Adhesives, Inc.		Synthetic resin packaging adhesives

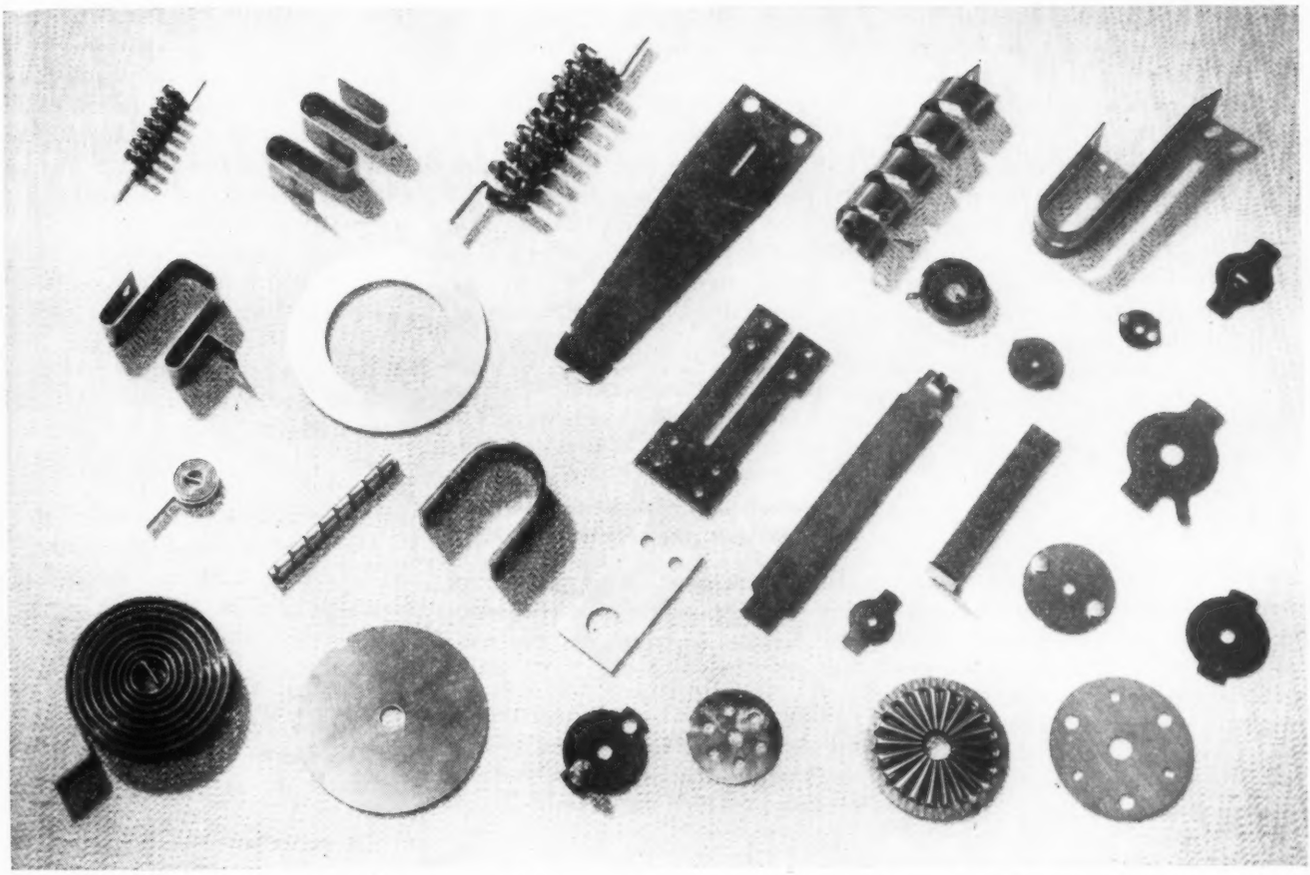


Fig. 1—Typical bimetal elements such as used in snap-acting and creep type thermostats for controlling temperature.

APPLYING BIMETAL THERMOSTATS

J. O. MOORHEAD
Engineering Department, Spencer Thermostat Company

Engineering analysis of basic factors in selecting and applying creep and snap action thermostats. Eight application considerations, direct and remote mounted thermostats, current and voltage type compensation, and effect of cup and plate type mounting on performance are among the topics discussed.

DESIGNERS can usually obtain reliable and economical automatic control of temperature by the proper selection and application of simple bimetal thermostats. Depending upon the design and operating requirements, a complete thermostat may be applied as a component or the bimetal elements may be integrated into the machine or device for simplicity and to obtain best heat transfer.

Generally, it is more satisfactory and economical to apply completely assembled thermostats. This is especially true of snap-acting thermostats of the disk type since their performance is peculiarly dependent on precisely controlled assembly methods. Built-in thermal elements usually require specialized engineering attention and techniques. Other factors that help decide whether a complete thermostat or a bimetal element should be used include type of action required, the quantity involved, type of application, and the availability of thermostat engineering talent.

The two general classes of thermostats are the creep type and snap action type, and typical thermal elements are shown in Fig. 1. Generally, the creep type thermostat is less expensive and can be more easily built for adjustable temperature control. But in many applications the use of gradual opening and closing of contacts is impractical and snap action of the electrical contact or a gas valve, for example, is essential. Snap

action can be obtained by using a bimetal thermal element with a magnet, toggle mechanisms, or by simply forming the bimetal in the shape of a dished disk.

The basic problems of applying bimetal thermostats to products that they control are the same. Heat must travel properly into and away from the thermal element by convection, conduction, and radiation so that the preset thermal element will consistently measure the temperature change in the apparatus that it controls.

For best performance of the final product, factors affecting the control thermostat should be considered in the early stages of the design of the product. Too often the thermostat application is considered after the apparatus is almost or completely designed and compromises are necessary. Often this makes an otherwise good thermostat do a bad job of temperature regulation because it is not properly applied, and rarely can it perform to best advantage when it is added after the design is completed.

Application Factors

Both the type of thermal element and the construction of the thermostat using the element is determined by the type and construction of the product with which it is to be used. To properly select the best thermostatic construction, application facts such as the following should be known and considered.

RANGE. Over how many degrees it is desirable to adjust the thermostat? A fixed temperature thermostat is simpler and more tamper-proof. If adjustable type is required, specify the exact range.

DIFFERENTIAL. The larger the operating differential the longer the life. Generally, a wider effective differential must be allowed for a snap-acting thermostat than for a creep type.

OVER TEMPERATURE. What is the maximum temperature over the operating or adjusting range that the thermostat will be subjected to? Certain types of thermostat constructions can withstand more override than others.

CONTACT RATINGS. This, to a large degree, determines the size of the thermostat. Contacts must have ample capacity to carry and rupture the specified load. If necessary to rupture d.c. loads at above 30 volts, this is a major factor in determining the contact construction. Electrical insulation through air and across insulating surfaces must be sufficient for the voltage and type of load that is to be controlled. The Underwriters' Laboratories' specifications are the accepted standards for these spacings.

VIBRATION. If subjected to severe vibration, the construction must prevent change of the controlling points or in the structure of the thermostat. Any vibration is usually objectionable in a creep type; moderate vibration may aid the snap-action type.

HEAT RESPONSE. This in a large degree determines the type of thermostat because it determines the mass and mounting relation.

CORROSION. For corrosive conditions, the thermostatic element and general thermostatic construction is made of corrosion resisting materials.

USEFUL LIFE. The number of cycles during its useful life determines partly type of thermal element, contact construction, and also influences general construction.

When a thermostat is applied to control the temperature of an electrical appliance or other device, it is best to locate the thermostat or thermostats at the point or points where the temperature is to be controlled. This is much simpler than when physical size, type of construction, or convenience make it necessary to place the thermostat at some other location bearing a relation to the controlled temperature point. When remote location is required, it aggravates the ordinary problems of heat transfer, rates of temperature change, proper mounting, and materials used in the thermostats.

Integration into Product

When designing products that are thermostatically controlled, the mounting and applying of the thermostat should be done when the product is in the drafting board stages.

An example of the proper integration of thermostat control into a difficult design is shown in Fig. 2. Since the thermostat for this sterilizer was to be placed remotely from the water it controlled, early in the design a special well was provided in the main casting for the thermostat so it would receive proper heat flow. Placing the thermostat in the casting of the container near the electric heaters instead of directly in the water, protects the thermostat from corrosion, electrical connections are simple, and no space is subtracted from the inside of the container. But by gaining these advantages the problems of proper thermostatic control are increased. The thermostat must be applied in such a way that its thermal elements will follow the temperature of the water under the most severe conditions such as fast rates of temperature change, under-voltage, and any similar abnormal conditions.

With the thermostat in the natural location under the cast brass container and between the electric heating elements, the temperature of the thermostatic element can rise faster than the water in the container. In this overcompensated condition, if the thermostat is set to open its contacts at a temperature corresponding to the desired water temperature, the water temperature would be less than desired. Setting the thermostat at a higher temperature so that it opens its contacts at some temperature corresponding to the differential between the thermostat setting and the desired water temperature does not solve the problem.

The difficulty is that functioning depends on a definite rate of rising temperature in a given ambient with a certain wattage input for accurate results. If the voltage changes, the wattage input and the rate of rise both change and thereby changing the relation between the water temperature and the opening temperature of the thermostat. A change in the ambient around the sterilizer also alters the rate of heat flow thereby affecting the relation between the thermostat opening temperature and water temperature. A similar relationship occurs if the temperature of the thermal element does not increase or decrease as fast as the water temperature. In the undercompensated state, the rate of change affects the closing as well as the opening points of the thermostat in relation to the water temperature.

It is not necessary to have the ther-

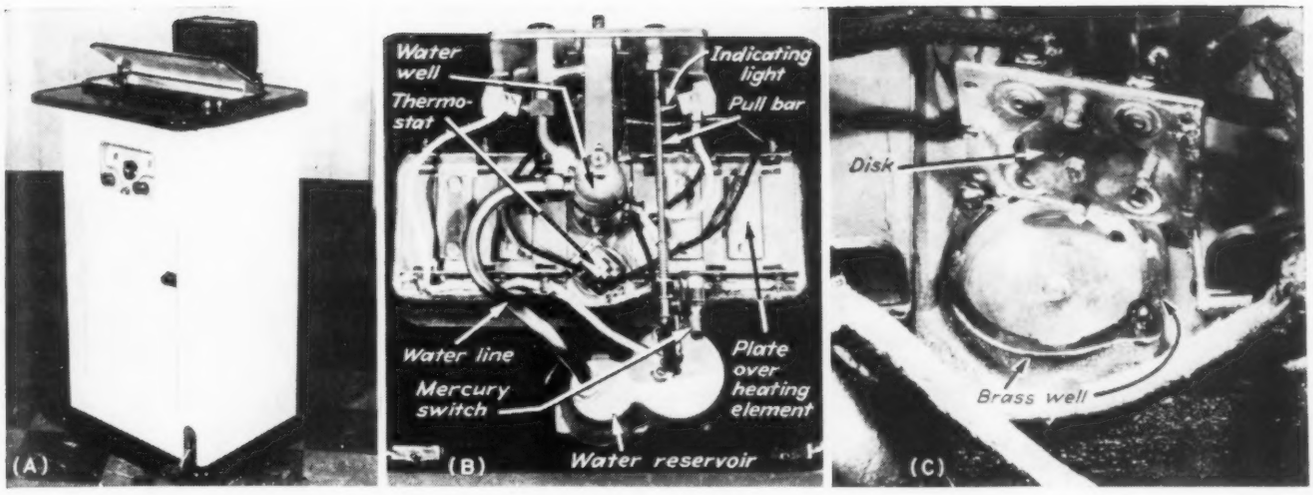


Fig. 2—Remotely located thermostats to control temperature should be considered early in design of product. (A) This sterilizer design provides a special well in its main casting for the thermostat. (B) Thermostat is located between the electric water heaters. (C) The well is a brass instead of iron casting to provide best heat flow for the application.

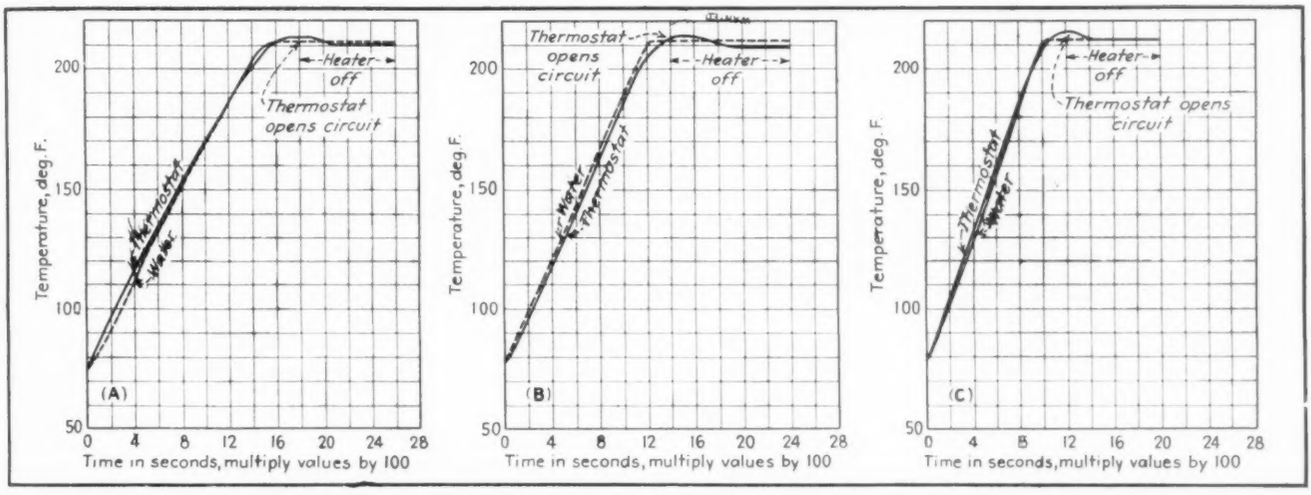


Fig. 3—Effect of different a-c voltages on the performance of remotely located thermostat controlling water temperature. Curves show three conditions. (A) Normal voltage, 115 volts. (B) Undervoltage, 100 volts. (C) Overvoltage, 125 volts.

mostat operate at the same temperature as the water provided the proper application is made, enough variation in water temperature is permissible, and the thermostat is properly compensated. When the thermostat must operate at a different temperature, extensive testing must be done under all maximum and minimum conditions to which the appliance will be subjected.

In this sterilizer thermostat application, the thermal element of the snap action theremostat follows closely the temperature of the water being heated. The thermostat is mounted in the cast well, as shown in Fig. 2(*C*), with a machined surface to provide good surface contact between the base of the thermostat and the cast metal water container. The better the conduction of the metal container the better will be the heat response of the thermostat. Therefore, a brass casting is used instead of an iron casting, for example. The snap action thermal element extends down in the well so it is surrounded by the temperature of the casting. Thus the thermal element receives heat from the casting by conduction, radiation, and convection without being disturbed by any harmful air currents. The outside casing of the sterilizer creates a partial dead air space around the thermostat and casting assembly thus insulating it thermally.

To check the response characteristic of the thermostat, a thermocouple made from 0.010 in. dia wire, to keep the thermal mass to a minimum, was attached to the thermal element. A similar thermocouple, with a small piece of copper soldered to the junction to add mass and obtain more of an average water temperature, was placed in the water container in a central location. With the water, thermostat, and all parts of the sterilizer at a room temperature of 75 F, ±5 deg. at the start of the test, curves were plotted of temperature against time for normal, high, and low voltage.

For both normal and abnormal voltage the thermal disk of the thermostat followed the water temperature very closely as shown in Fig. 3. The two temperatures change their relation slightly from one voltage to another and at different points of the heating cycle at a given voltage, and part of this change of relationship is probably caused by testing error. But where temperatures follow this

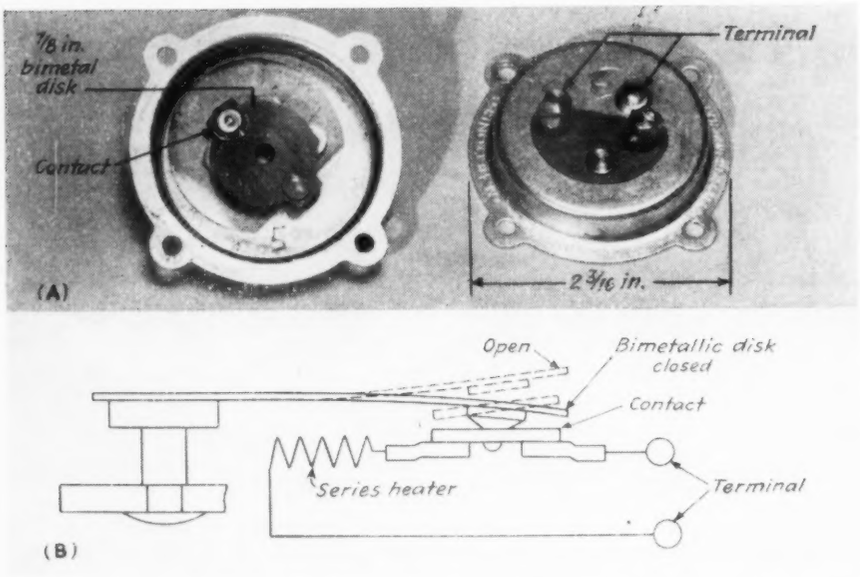


Fig. 4—Typical thermostat with heater-cup type base. An additional flat metal mounting plate adds thermal mass to produce uniform results. (A) Front and back view. (B) Circuit diagram of series heater showing path of current flow.

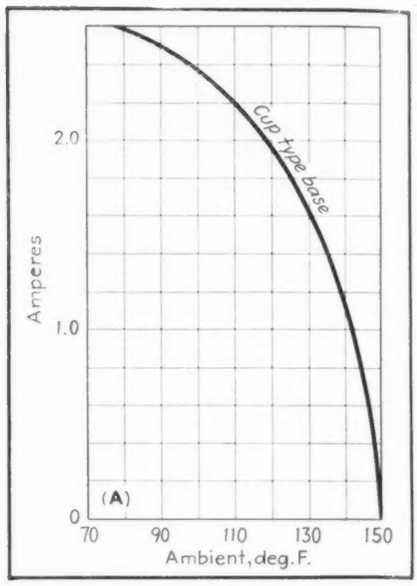


Fig. 5(A)—Ultimate trip current for different ambients of thermostat in Fig. 4. Values were obtained by test.

closely, variation of ambient surrounding the appliance will not affect performance appreciably. In this application, the thermostat does not turn off all the electric heaters when it opened its contacts. Thus, if the cover over the water tank is left closed the water will continue to boil with the heaters that remain on, therefore, the thermostat will not close its contacts. But if the lid is opened, the water and thermal element will cool sufficiently to reclose the thermostat contacts and apply full wattage to the sterilizer.

Compensation

It is always best to apply the thermostat so that it can follow the changes in temperature of what is being controlled by some method of direct heat transfer. When it is impracticable to do this directly, auxiliary heat sources are used to obtain desired temperature regulation. If this heat is produced within the thermostat, in the snap action type this additional heat can be used to reduce the natural differential of the thermostat and also make the thermostat follow more closely the temperature it controls.

Where bimetal thermostats open an electric circuit on temperature rise the current is merely passed through the bimetal and generates heat in the element by the I^2R loss. In general, such current type compensation is inflexible because the resistance of the bimetal must be changed for every current change passing through the bimetal. Relatively, this resistance change is limited for a given type of thermostat design. A more practicable method is to pass the current through a current type resistance heater built into the thermostat in a definite relation to the thermal element. For certain ranges of current, similar flexibility can be obtained by passing the current through the bimetal element in series with the compensating built-in heater. The heat produced in the thermostat is the sum of that produced in the bimetal plus that produced in the heater. For certain applications of varying current this combination often gives the best results.

Tests on the bimetal thermostat in Fig. 4 show the effect of heat generated in the thermostat on its opening temperature when the thermostat contacts were opened on temperature rises. The current passes only through the compensating heater and not through the bimetal snap-acting disk. The thermostat is mounted on a flat metal plate, thus adding thermal mass to obtain uniform results. The calibrated opening temperature of the thermal element was 150 F. In an ambient of 75 F the current passing through the compensating heater was slowly raised in small steps and the temperature was allowed to equalize after each step. This procedure was repeated until the thermostat opened. This value of current squared times the resistance of the heater gave the wattage to compensate the temperature of this thermostat at 75 F. The current values were obtained at ambients to plot Fig. 5(*A*). By calculating the wattage developed in the thermostat to make it open its contacts at various ambients, gives Fig. 5(*B*). For example, in a 90 F ambient it requires 2.5 amp to open this thermostat that is calibrated to open

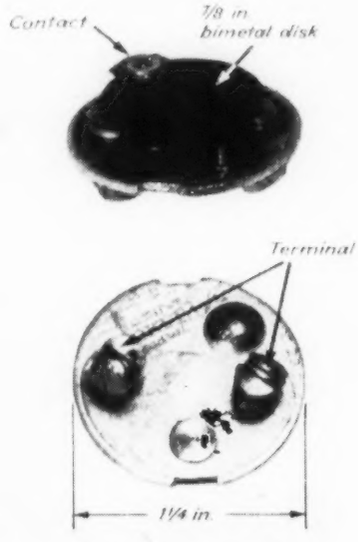


Fig. 6—Themostat with heater mounted on flat plate base. A series heater is used as shown in the sketch Fig. 4(*B*).

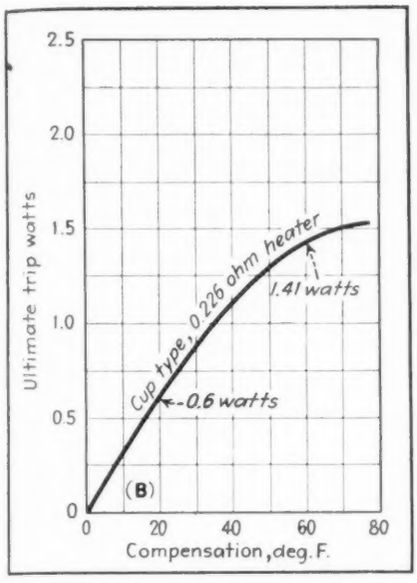


Fig. 5(B)—Ultimate trip wattage for degrees of compensation of thermostat in Fig. 4. Values are calculated.

at 150 F. Since the resistance of the heater in the thermostat is 0.226 ohm, watts $= I^2R = (2.5)^2 \times 0.226 = 1.41$ watts to raise the temperature from 90 to 150 F or a temperature rise of 60 F. This places one point on the curve in Fig. 5(*B*) and others are calculated in a similar way.

From Fig. 5(*B*) the wattage that must be generated in this thermostat to give a desired amount of temperature compensation can be determined. For example with 2 amp flowing through the heater, to obtain 20 F temperature compensation requires 0.6 watts as shown in Fig. 5(*B*). Since resistance = watts/(amp)^2 = 0.6/4 = 0.15 ohm required in the heater to give 20 F compensation with 2 amp flowing through it. This compensation is obtained only under the exact conditions at which this thermostat was tested and only for this thermostat construction. If the rate of temperature change, mass, or thermostat construction is changed the compensation characteristics will change. But using Fig. 5(*B*) as a guide and knowing the conditions under which a thermostat is to operate, an experienced designer can estimate the approximate wattage that should be generated in the thermostat. If the thermostat is used where the rate of temperature rise is greater than that under which it was tested, more wattage is required to obtain the desired compensation. If the estimated wattage gives too much or too little compensation these known values can be put on the graph as a guide to how much these values must be changed to give the proper results.

The limiting factors that determine whether it is practicable to put the right wattage in a given thermostat are the diameter of wire that can be used and available space for a heater. For large currents, the diameter of the wire must be large to give low resistance and there is a limit in the diameter that can be assembled into a given thermostatic construction. For low current voltage type heaters, the usual problem is getting enough resistance into the heater in the available space. In addition, supporting the small diameter heater wires may be a problem and if the resistance is high, the voltage drop across the heater may be a limiting factor.

A comparison of performance of thermostats constructed as shown in Fig. 4(*A*) and Fig. 6 is shown in Fig. 7 by curves.

Temperature compensation also can be obtained in thermostats that close their contacts on temperature rise. In these fan or cooling type thermostats, when the contacts are open the heater is connected across the line and when the contacts close they short out the heater. High values of resistance are used to obtain the necessary low wattage. For instance, for 115 volt operation the resistor heater must be around 30,000 ohms. The current for the heater passes through the apparatus when it is not operating and if this is objectionable this type of compensation cannot be used. For the same compensation, the voltage type heater must be changed if the applied voltage is changed. But compensation is not affected by change of current through the main circuit. Only the closing temperature is compensated. The heater is shorted out of the circuit when the opening temperature is being approached. Because of its mass, residual heat in this type of heater tends to defeat the action of the heater. For fast rates of temperature change residual heat also is a factor.

When compensating heaters are used in thermostats, the application must be tested under simulated service conditions, such as varying ambients, voltages, and velocities of air currents passing over the apparatus. When a compensating heater is used both the main heat supply of the apparatus and the heat generated in the thermostat affect performance. Sometimes changes of conditions affect one heat source differently than the other, and hence accuracy.

On new designs, full knowledge of application requirements and testing under all the extremes of working conditions is the best safeguard.

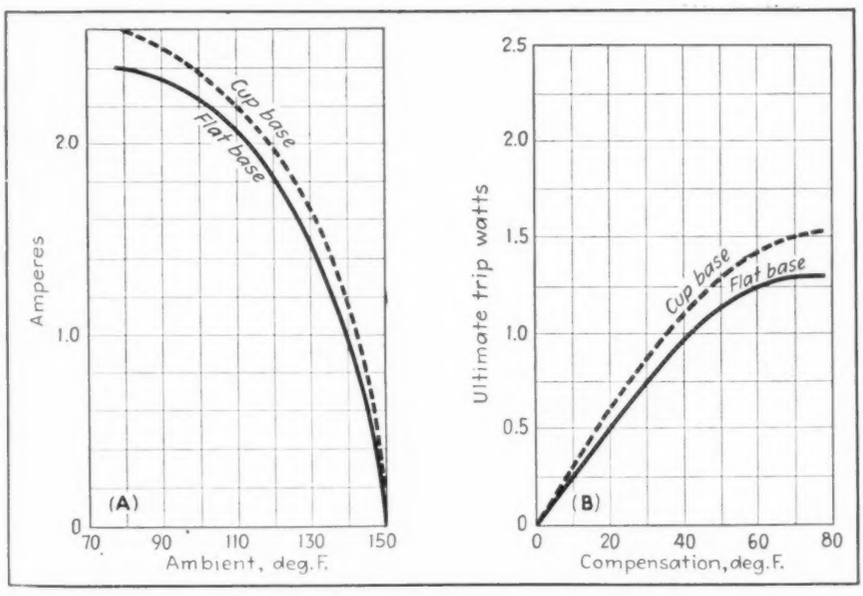


Fig. 7—Construction alters performance. Using 0.226 ohm heater, solid curve shows flat plate base and broken curve shows cup type base. (A) Ultimate trip current for different ambients. (B) Ultimate trip wattage versus compensation.

Electrical, Mechanical and Fluid

Operating principles of these variable speed transmissions are similar to those discussed in Part I of the article, with the exception of the unit using a disk and sliding roller. Materials are indicated where they are of interest, and limitations of the units are noted.

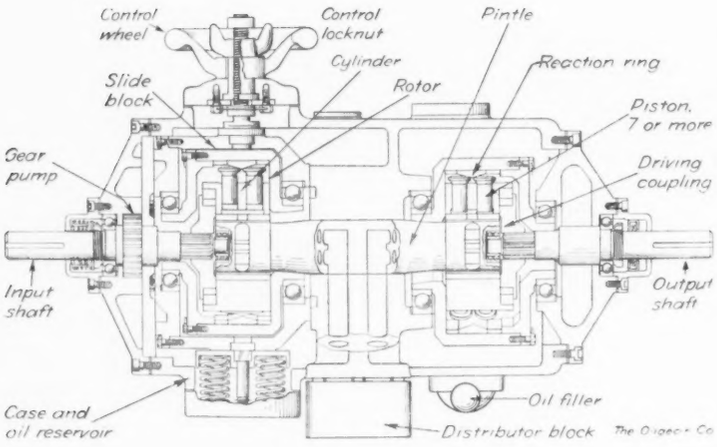


FIG. 9—The Fluid Power transmission is made of a radial multiple piston, volumetric, variable displacement pump driving a similar, constant displacement motor by a volume of oil forced through the drilled and cored passages. The input shaft is driven in a clockwise direction by any constant speed source. Oil is delivered to the output unit, turning it over from zero to maximum speed in either direction, by controlling the eccentricity of the driving unit rotor; the output rotor operates at a constant eccentricity. A built-in, adjustable, differential-type, relief valve protects the power input mechanism, the transmission and the driven machine against overload, and a pressure gage can be placed in the output system to indicate the actual load. The gear pump maintains back pressure on fluid power system always.

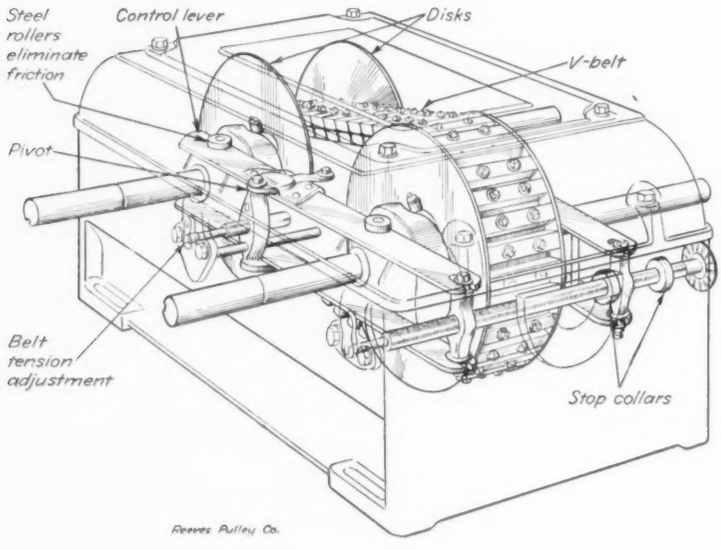


FIG. 10—Known as the Reeves Variable Speed Transmission, this unit can deliver more or less turns than its power source by using the principle of changing diametrical pitches. Two pairs of semi-steel, cone-shaped disks are double-key mounted on parallel shafts. The pairs of disks are connected by a V-shaped, metal belt that fits the throats formed by the pairs of disks. The disks are laterally moved on their shafts by two levers pivoted midway between the shafts. Operating at variable horsepower but constant torque, either shaft can be used as the variable speed shaft. The shaft connections from the driving source and to the load can be of any type, and can be made on the same side of the transmission.

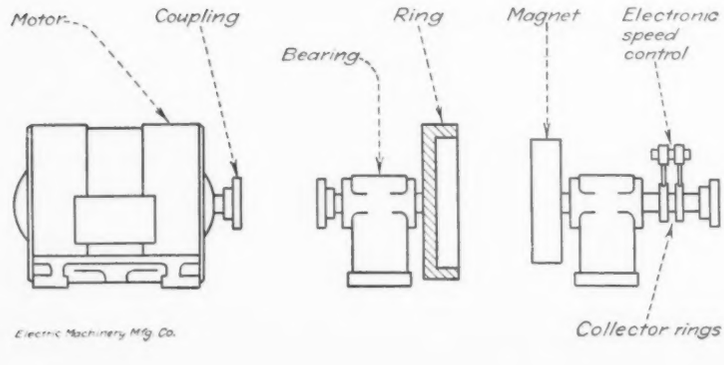


FIG. 11—Used on applications where the load torque drops off rapidly with a reduction of speed, the E-M Adjustable-Speed Magnetic Drive System is made up of a constant speed motor driving a ring. Free to rotate within the ring is a magnet that is coupled to the load shaft. The constant speed motor can be either a synchronous or squirrel-cage alternating current type. The poles of the magnet are excited by direct current through collector rings on the magnet shaft. The speed of the output shaft is varied by controlling the pole excitation. Automatic control can be had by using an electronic control unit. The rate of speed change of the load is dependent on the inertia characteristics of the load.

Variable Speed Transmissions—II

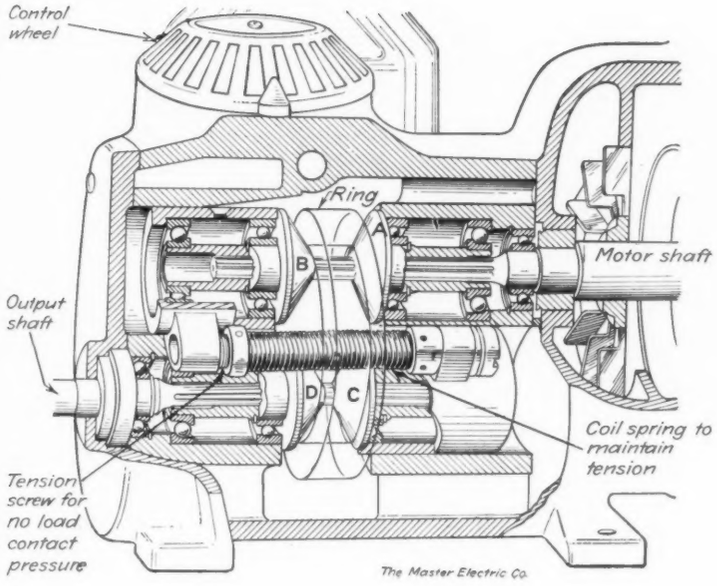


FIG. 12—Made of alloy steel, the driving and driven pairs of cones on the Speedranger are connected by a power transmitting alloy steel ring. The driving cones A and B are splined to the motor shaft, and the driven cones B and C are mounted in rigidly connected sliding bushings. When the controlled bushing moves, the other bushing moves an equal amount. The axial movement of the sliding bushings is controlled by a rack on the top bushing that meshes with a pinion driven by the handwheel. The sliding bushings are mechanically connected to form one unit by a special screw passing through a lug attached to each bushing. The tension of this screw determines no-load contact pressure between ring and cones. The screw is surrounded by a coil spring adjusted to maintain original screw tension. The contact edges of the ring are specially generated curves that cause the ring to wedge into the angle of the cones when load is applied. This increases the contact pressure in direct proportion to the load; insuring good traction at all load conditions within the rated capacity of the unit.

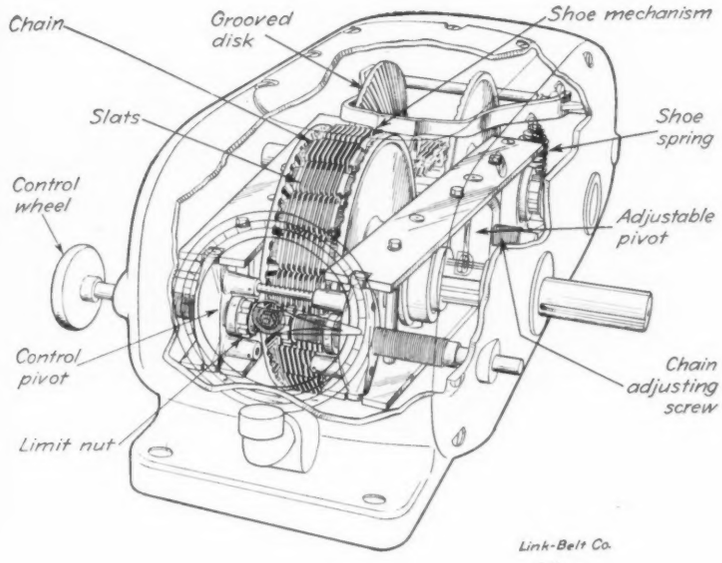


FIG. 13—The P.I.V. Gear is a positive chain drive giving an infinite number of speed variations with no slipping. It is made of a self-tooth-forming chain that runs on the grooved faces of the conical surfaced alloy steel wheels. The handwheel moves the control levers about their central pivots changing the ratio of the effective diameters of the wheels. The wheels are mounted on splined shafts and are free to move laterally. The chain links are made of transverse slats that can move. These slats, forming the power transmitting teeth, are forced into the wheel grooves. A shoe mechanism, with spring tension, applies pressure to the slack side of the chain, which forms the side teeth and also helps to keep the chain in adjustment.

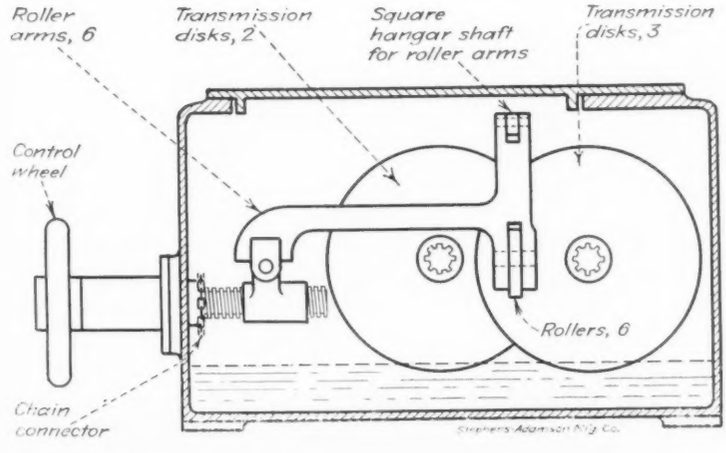


FIG. 14—The Changemaster is made of two shafts on which are mounted steel disks in overlapping relation. Between the disks, and outside the end disks, are steel rollers arranged in line so that rollers engage disks on either side. The speed of the driven shaft depends on the relative positions of rollers between driving and driven disks. The control screw moves all the rollers to a larger or smaller disk diameter to change the speed. The pressure needed for positive action is automatically regulated in proportion to the load transmitted. An extra cam-roller on each outer roller-arm is seated in a semi-circular cam. As transmitted load increases, cam rollers tend to move up or down, depending on direction of rotation, increasing the pressure between the rollers and the disks. Oil on thin disks lubricates without churning losses.

ENGINEERING ABSTRACTS

FOREIGN AND DOMESTIC ARTICLES

The Shaping of Die Forged Parts

Foreign abstract, condensed from "Die Gestaltung von Gesenkschmiedestucken" by Hans Maller, in V.D.I. Zeitschrift, Dec. 25, 1943, page 809.

DIE FORGING is a shop process intended to reduce material and labor costs and to shorten the time of completion of a given part. Well-designed and well-constructed die forgings need be machined only slightly and show little waste of material. Full cooperation of the designer of the part, the designer of the dies in which the part is formed and the pressman is essential. Many tools, dies and jigs may be available, but the selection and application of them are not delegated to the pressman. These tools are specified by the designing and the finishing engineers. Die forging embodies its own laws. For instance, thin walled parts with large areas to form offer the greatest resistance to a change in form and can be made only by forging with a drop hammer. When designing drop forgings, care must be taken to provide ample clearance for lifting out the completed parts. Slanting walls with a slope of 1 to 10 on an outside surface and a slope of 1 to 7 on an inside surface are common. If sloping walls are not permissible, the piece must be machined to cut away metal to straighten the walls. Die forged parts require less surface draft; consequently, the machining cost of them is less. To assure minimum internal stress and long die life, all corners in the dies should be well rounded to offer minimum resistance to the flow of metal within the forms. Corners, grooves and hollow spots influence both the part design and the amount of machining required.

Because of the tremendous demand for die forged parts it is advisable to ascertain whether die forging is necessary. Oftentimes the desired parts can be fabricated just as well by welding, broaching or stamping.

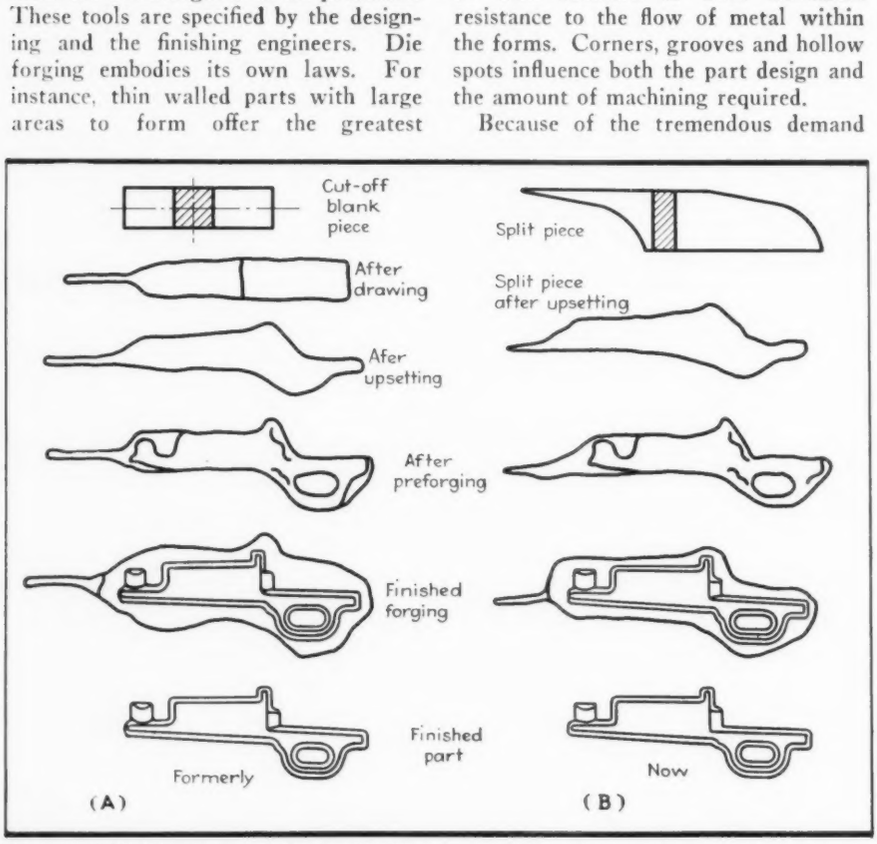


Fig. 1—Splitting process (B) provided savings of 12 percent of metal, 55 percent on gas consumption and 28 percent in forging time. Drawing is not required.

SPLITTING PROCESS. The custom of pre-forging the piece approximately to the shape of the finished part results in a considerable amount of surplus metal. To avoid this surplus the splitting process was developed in Solingen, several decades ago. The term "Splitting Process" sometimes leads to the wrong conjecture that there is a longitudinal splitting of the parts, like that of wood patterns, but this is not the case. Instead, the word "splitting" refers to the cutting off, from a metal half, of a cross-sectional end piece that will fit into the die with small clearances. The part shown in Figs. 1 (*A*) and (*B*) is a typical example. Formerly, this half part was drawn from square bar stock, before being placed in the die press. The present splitting process not only eliminated the drawing time, but also effected savings of metal and in fuel gas consumption.

Shapes of the blank pieces produced by the splitting process can be developed so as to reduce the metal wasted in finishing the part. Fig. 2 illustrates two split pieces that ultimately become the same part of a forceps. Less metal is lost in the fins with the split piece of Fig. 2 (*B*) than with that of (*A*), which has the simple 28 by 12 mm. cross section. Although the loss of metal in fins for one pair of forceps is small, 16,800 kg. of metal were saved through the revised splitting process on 120,000 pairs. The splitting process is often used in the fabrication of flat shaped metal halves of unusual cross section when the number of parts required is not great enough for commercial fabrication by rolling.

FORGING OF HOLLOW PARTS. Die press machinery can be used with

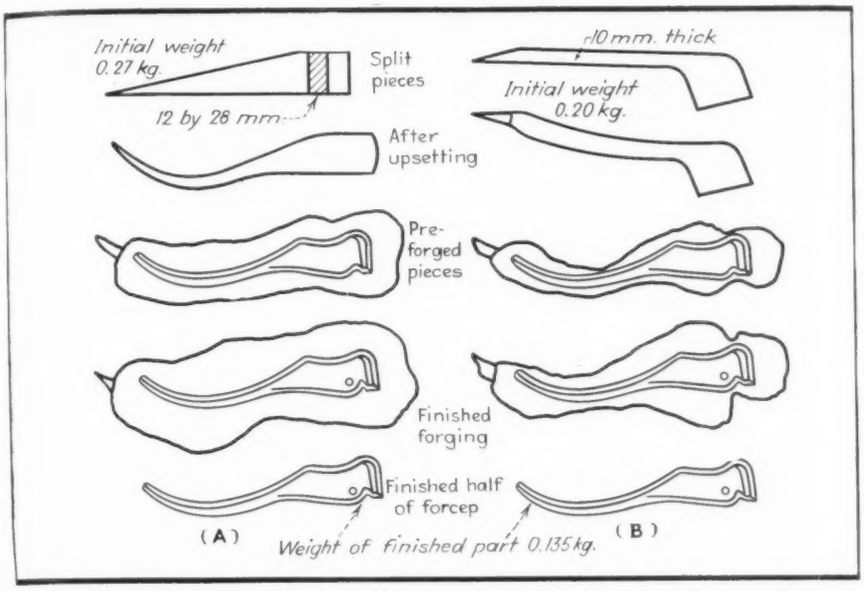


Fig. 2—Changing from split piece (A) to that of (B) saved 16,800 kg. of metal in 120,000 pairs of forceps. Spitting process is used in forging flat shapes.

excellent results in pre-forging hollow chambers and borings in parts. The flange at the shaft end, Fig. 3 (*A*), was originally pressed on. This represented an improvement in construction efficiency when compared to the turning of the finished piece out of the solid metal. A still better construction is made available with the aid of the die press as is shown by Fig. 3 (*B*), (*C*) and (*D*). Forging hollow spaces by means of the die press offers the advantage of lesser consumption of metal and the much closer approach of the die contour to the finished surfaces of the part, which also reduces the time required for fabrication. Two shaft ends can be made from a piece of steel shafting which is 70 mm. in diameter and 550 mm. long. When the hollow space in the end of the first shaft end has been completed, the opposite shaft end is reheated and is hollowed by the press. In this way the butt resulting from one hollowing press operation is ejected and is used as a long end for the next piece. The hollow space in each shaft end is enlarged slightly by the stamp in such a manner that only a small, circular ridge is formed around the flange. This ring and the ejected butt are the only metal wasted.

Metal is displaced in the form during die pressing chiefly in the direction of the stamping, but the pressure exerted by the clutch cheeks can be made to do useful work in the transverse direction over small forming areas. If large changes in two directions at 90 deg. apart are necessary, the parts are first die forged and then formed by a forge press.

Flanges of standard high and low pressure valves, Fig. 4, can be pressed on, in which designs the upper and lower surfaces should be turned flat. The turning operation consumes much time. By upsetting the flange metal in a forging machine the need for convex flange surfaces is avoided. Large hollow body parts and rings with concentric cylindrical bores preferably should not be die forged because the preliminary forming does not even approach the finished shape. If the part is long, as well as large in diameter, even more metal will have to be provided. For such parts use of a forging machine and rolls is recommended. The rough rolled rings can be made to conform closely with the finished product. The output by the rolls is good. They also may be used to roll rings that have various cross sectional profiles.

To avoid the necessity for convex surfaces in die forged hollow bodies the bores sometimes are finished by means of a mandrel in an added operation, which converts the bore and external surface contour into a cylindrical shape. If the drawing process is repeated, it will accurately form the flanges. This procedure follows the basic principles of accurate forging.

CUTTING AND WELDING. Simplification of complex parts for fabrication by welding should always be kept in mind by the designer. In this way the overburdening demand from forging press shops can be curbed and the cost of the forged and drawn parts can be brought down. The spring housing

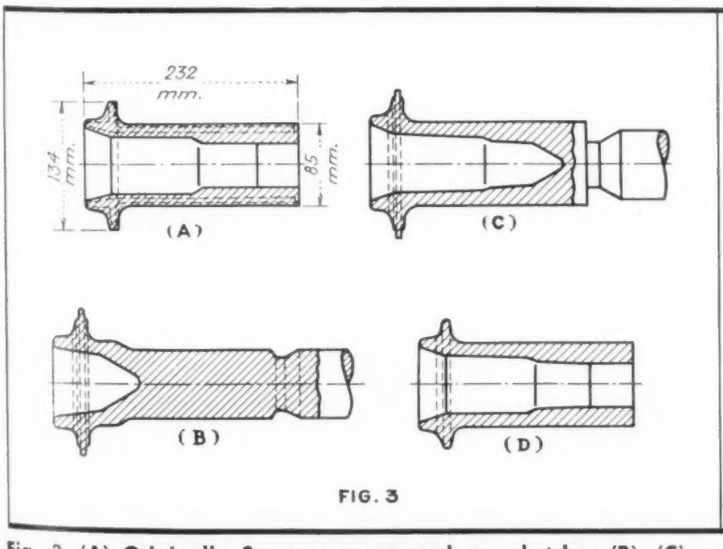


FIG. 3

FIG. 4

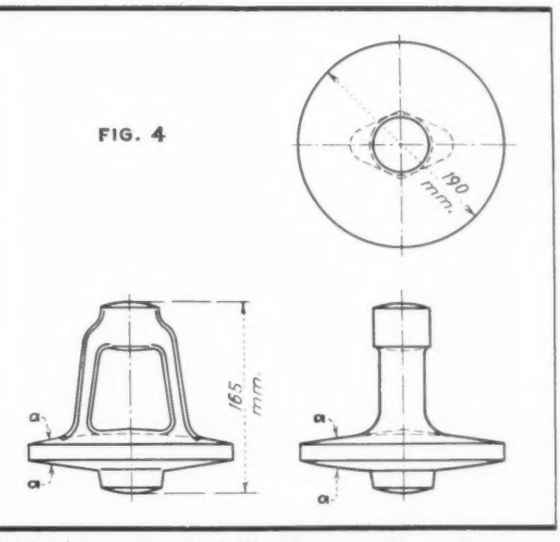


Fig. 3—(A) Originally flange was pressed on; sketches (B), (C) and (D) show steps in hollowing part in a die press.
Fig. 4—Convex plate surfaces on pressure valves can be dispensed with if the cover plate is upset in a forging machine.

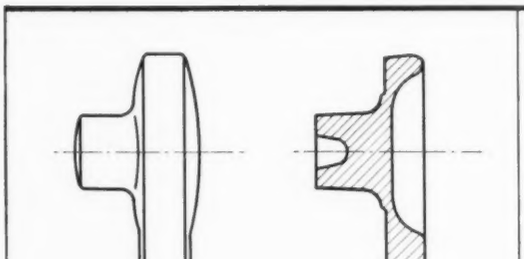


FIG. 5

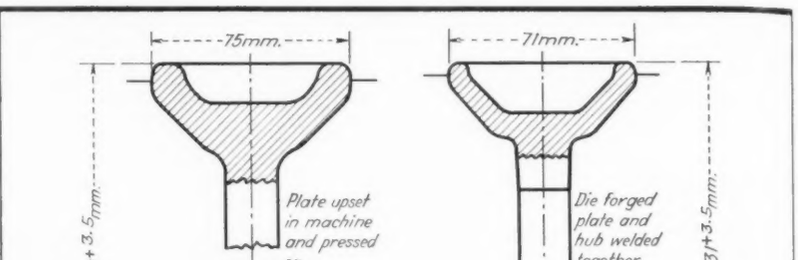


FIG. 6

Fig. 5—Welded handle facilitates forging of body and makes toward economy in use of metal. Fig. 6—Welded construction instead of forging allows close dimensions to be maintained without a subsequent machining operation.

shown by Fig. 5 (*A*) could not be forged in one piece because of the long handle. A more efficient design is realized if the handle is separately made and welded on.

Accurate forging operations often run into great difficulties. Also, in such instances welding points the way out. The head of the spindle coupling, Fig. 6, is die forged and the finished form is accurately retained. Boring is the only machine work required. The vertical head is welded to the shaft end. In contrast to the one piece forging, welding offers advantages on parts that are subjected to heavy fluctuating loads.

Another instructive example is given by Fig. 7, which shows a hollow forged rocker arm in process of fabrication. This method was developed by a die forge shop. The die press is used first to form the hollow piece (*b*) from the shaft length (*a*) which is then drawn into form (*c*). A head is added by upsetting as in (*d*), after which holes are punched, as in (*e*) and (*f*). A tube is welded on and is bent at right angle as illustrated by (*g*) and (*h*). Although hollow forging has not been fully developed, it has a promising future for difficult forming. Progress in the development of it should keep pace with that of welding.

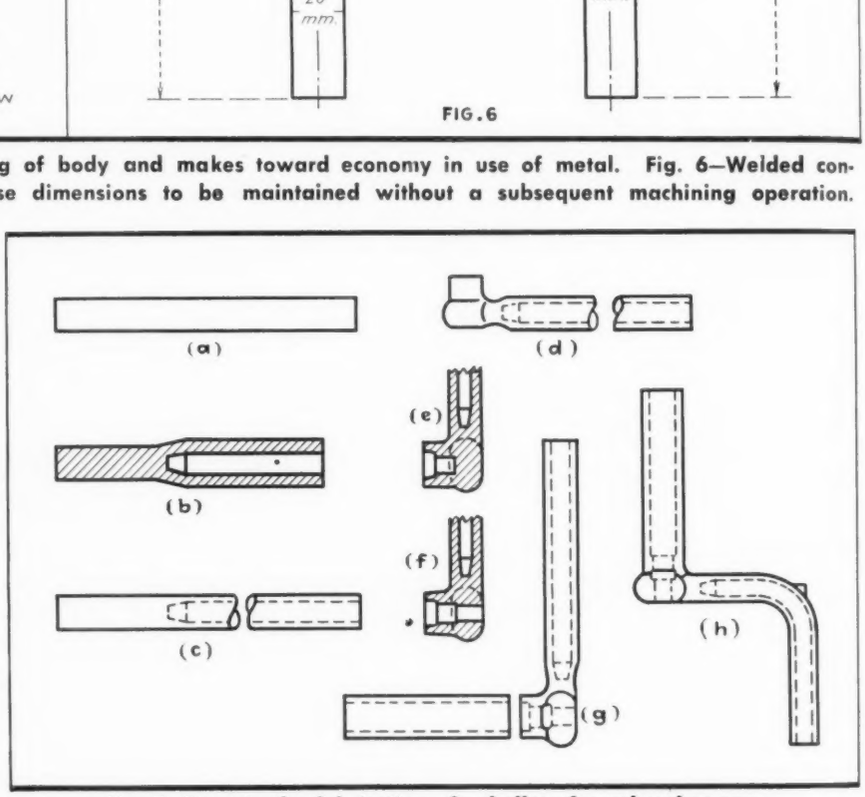


Fig. 7—Steps in the fabrication of a hollow forged rocker arm.

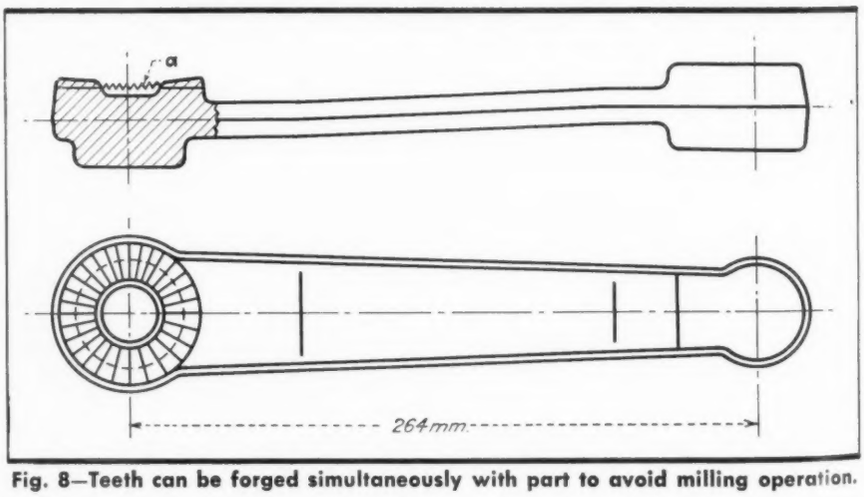


Fig. 8—Teeth can be forged simultaneously with part to avoid milling operation.

New Methods for Accurate Forming

The smithies have done considerable research in determining the best shapes for forged parts. They have gone their own way in this work and have not ceased in their efforts to bring about improvement. The most scientific problem of the smithy still is the accurate forming of parts. A definition of accurate forging would include the closest practical agreement in dimensions and shape of the preliminary forging with the part as designed and the obtaining of smooth exterior surfaces. To attain this goal, additional fabricating steps sometimes are necessary. Such steps include additional forging and stamping operations for parts that usually require this added processing only to obtain better fitting and smoother running surfaces. A few practical examples follow.

Bicycle crank arms formerly were forged with conventional convex sides,

which were flattened by milling to improve the appearance. The finished surfaces had clean rectangular corners. The flat surfaces are finished only by grinding.

Notch teeth (*a*) in one end of the brake lever, Fig. 8, are die forged together with the rest of the part. Hot forged parts, such as these, need no subsequent milling. At one heating the metal is drawn, beaten and the shoulders removed. The disadvantages of the new process are reduced life of the die and a smaller output, which in turn, are counter balanced by the elimination of the 40 minutes milling time.

The die forging of thin walled parts, likewise, has made important progress. In this connection it is up to the designer to so shape all pieces that they will fit readily into the forging die. He must be careful, not to adopt foundry standards for cast parts, when the parts are specified to be die forged. Stiffening ribs can be beaten if they run in the same direction as the hammer blows. In the die press, the metal rises more rapidly than it can be upset vertically by the die forging.

The die forged switch knife, Fig. 9, is an outstanding example of what an improved design of a part can do. In the initial design the forging and shoulder removal had to be done in two phases because the fork did not run in an axial direction as is indicated by dash lines in Fig. 9 (*C*). It would have been, then, only necessary to turn the forged fork 90 deg. ahead of the present position. The profile of the switch leg between the axle and the fork did not permit this tortional twist. At the request of the smithy the profile was changed to a circular cross section. This corrected the condition and resulted in a saving in the forging operation.

Despite the difficulties that beset the die forging of thin walled parts, such as high forging pressures and short die life, it is in wide usage. A die forged housing formerly was made to the shape shown by Fig. 10 (*A*). This part weighed 29 kg. The marked differences in cross sectional shapes and area made it unwise to forge the shank portion any thinner because die forging requires careful distribution of the worked metal. As the quantity of this part became more and more in demand and the milling operation constituted the major share of the cost, a new design and a better fabricating method was in order. Development led to the design shown by Fig. 10 (*B*), which weighed only 24.5 kg. The forging of the thin zone, which is only 10 mm. thick, loads the dies heavily. An extensive, accurate pre-forging operation is necessary. A completely satisfactory distribution of the metal in pre-forming by open forging is not obtainable. It therefore becomes necessary to use a pre-forming die. Further to reduce the

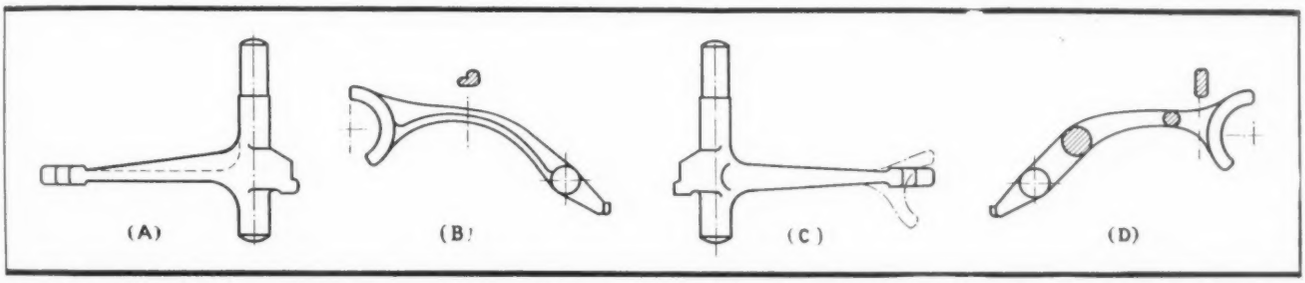


Fig. 9—Round section (D) permits arm to be forged in one plane with axis and then twisted 90 deg. to finished shape.

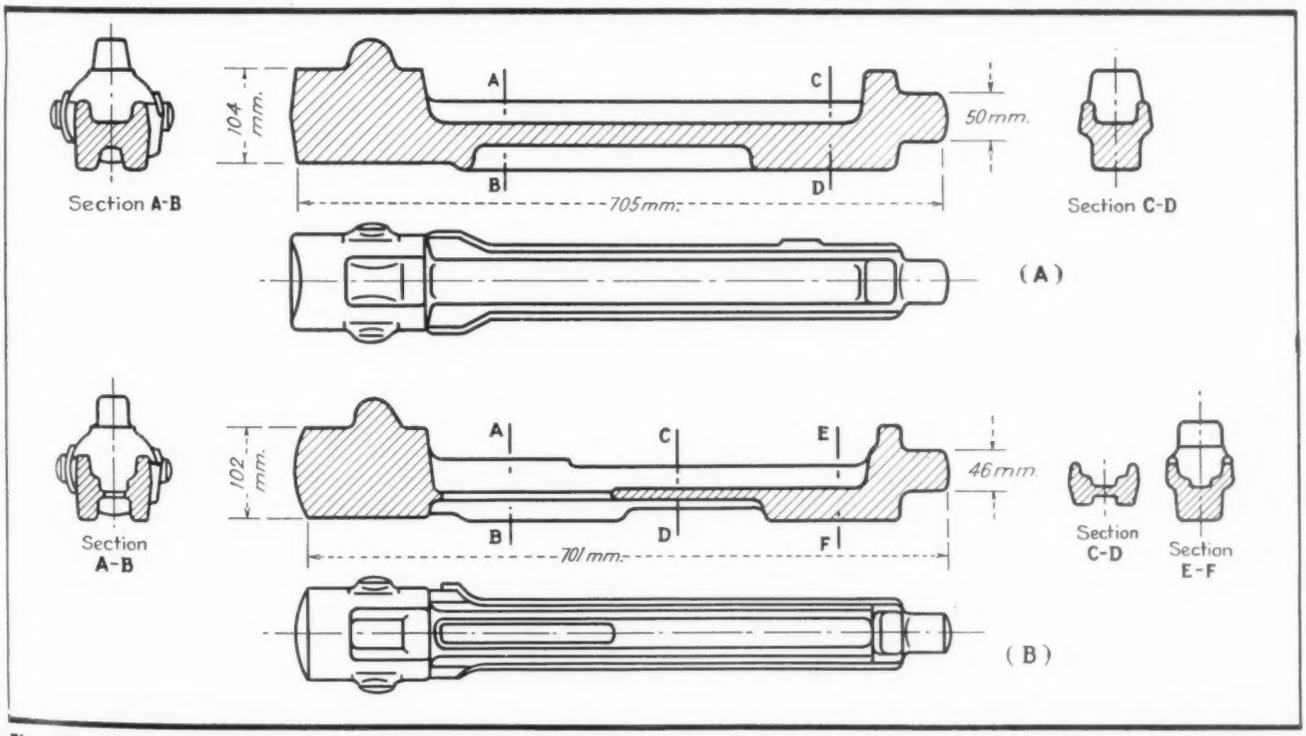


Fig. 10—(A) Forged part, weighing 29 kg., has to be milled after forging; (B) long hole is stamped in section 10 mm thick after forging. Part weighs 24.5 kg. as redesigned. An extensive, accurate pre-forging operation is necessary.

milling cost, the long slot in the shank was punched out.

Parts of variable cross section always present great difficulties in pre-forming them by a die. Some of the troubles are overlapping of the metal at cross passages, punctures and possibly the loosening of the die anchorage by side reaction to heavy forging blows. Parts such as those illustrated in Figs. 9 and 10 must be pre-forged with care. A new fabricating method not only avoids pre-forging altogether but also absorbs side thrusts. Several parts to be forged are selected and placed together in such a manner that no abrupt changes in cross section exist during the pre-forming operation. In one instance three draw bars and one chain link were forged together in half section in the same die. The shoulders that formed between the separate pieces did not influence the flow of metal and they were easily sheared off by stamping. The advantage of the system is the fact that equal cross sections of metal are forged at the same time. Likewise side thrusts are absorbed during the forging process and no pre-forming is required. While such a procedure is not recommended for general practice, it nevertheless shows the efforts being made by smithies to overcome their production problems.

Totally-Inclosed High Temperature Motors Use Silicones

From a talk "Higher Ratings for Totally-Inclosed Non-Ventilated Motors by Using High Temperature Insulation" by W. H. Formhals and G. P. Gibson, Westinghouse Electric Corp., presented at the Westinghouse Machine Tool Forum, April 22, 1947, Buffalo, N. Y.

USE OF SILICONE RESINS for winding insulation and silicone grease for bearing lubrication make it practicable to build the 3 and 5 hp. 4-pole totally inclosed non-ventilated motor on the same frames as those used for open motors.

These motors have comparable torques and the efficiency and power factors are only slightly lower. Although the total loss is about the same, they run much hotter than standard open motors because of the relatively small radiating surface for the heat loss. The use of these high temperature totally-inclosed motors for built-in applications should be no more difficult than for the physically larger standard types of totally-inclosed motors since the losses are practically identical.

While no definite standards have been set up for machines with silicone insulation, the American Institute of Electrical Engineers has tentatively established a permissible temperature rise of 140 deg. C. for Class *H* insulation. This is almost three times that for Class *A* (55 deg. C.) insulation and should permit the building of a much smaller machine for totally-inclosed non-ventilated motors.

A few motors have been built recently on the 254 frame for the 5-hp 4-pole rating. Double glass silicone bonded wire is used for the stator coils. When compared to the standard Class *A* totally-inclosed non-ventilated motor on the 326 frame, there is a considerable difference in size. The smaller size of the silicone insulated motors should simplify mounting problems.

These high temperature motors were built with standard open motor cores and have efficiencies, power factors, and torques comparable to those of the open motor. With certain modifications in the winding it is probable that the efficiency and power factor will be improved so the overall performance will be comparable to the standard open machine.

Research and engineering laboratories have been working with silicone varnishes and materials for about ten years and during that time many tests have been run on the basic materials and on completed equipment. Silicone was used in a Westinghouse motor for the first time in 1942. The only silicone material available then was a dipping varnish. This motor was tested on a 506 deg. C. winding temperature for a short time. The volatile components of the non-silicone insulation were driven off at this temperature. The stator was then revarnished and the motor again put on test. After 3,376 hours operation at 250 deg. C. a bearing failed and the tests were terminated. The stator was still in good condition.

Since 1942, many additional machines have been built incorporating the new developments in varnishes and insulating materials. In each instance, carefully followed tests were made to: (1) Determine the relation between operating temperatures and life for silicone insulation in the range of 200 to 300 deg. C. and (2) obtain a comparison of Class *A*, Class *B*, and silicone under similar conditions.

The test cycle adopted was: (1) Humidification for 24 hr. at 100 percent relative humidity; (2) drying at 100 deg. C. for 1½ hr. and at 140 deg. C. for 8 to 12 hr.; (3) high temperature run for 1/25 of the expected life of the insulation at the temperature of that particular test, with the intention of running each machine 25 cycles; and (4) silicone insulated motors were operated at the following temperatures: 200, 240, 280, 300 and 310 deg. C. by resistance. Insulation resistance, capacitance, dissipation factor, and high potential tests were taken at various stages of each cycle.

A motor operating at 310 deg. C., and one operating at 300 deg. C. failed after more than 5,100 hr. A second motor operated at 300 deg. C. ran more than 6,600 hr. before failing while one operated at 280 deg. C. ran more than 8,000 hr.

As a result of years of tests, it has been found that life of insulation is halved for each 12 deg. C. rise in operating temperature above a reference temperature point, or doubled for each 12 deg. C. drop below that temperature. Extending the above insulation life tests on this basis, the equivalent life at 180 deg. C. (the hot spot allowance tentatively given silicone insulated motors) for the motor tested at 310 deg. C. would be over 1,000 years. On this same basis, the tests at 240 deg. C. will have to be terminated because it is improbable that failure will occur in this century.

The failed stators have a very good appearance. That is, the windings are solid, and only a localized failure is indicated. Oxidation of the copper is suspected as the cause since there had been a uniform increase in winding resistance during the test that indicates a reduction in conductor area.

In contrast to these startling results with silicone motors, a Class *B* insulated motor treated with conventional insulation failed in 1,000 hr. at 200 deg. C. It was definitely an insulation failure. The winding was loose and the varnish completely evaporated from the glass and mica. Thus, tests prove that motors with silicone insulation are superior to those with Class *B* insulation.

When experiments were begun on silicone resins for high temperature windings, it was realized it would be necessary to develop a satisfactory lubricant for the bearings of such a motor if a balanced design between insulation and bearings were to be achieved. Therefore, experiments with a lubricant with a silicone base were coordinated with those for the resins. During the five years these experiments have been running, four different types of silicone grease have been tested. The fourth

type of grease tested has been in use for about two years and has proved satisfactory for this application. This grease has been tested in test-stands using a heating and cooling cycle and in the high temperature motors previously mentioned. To date there has not been a single bearing failure. Of greater significance is the fact that no sign of deterioration of either the grease or the bearings is apparent.

Results of Comparative Tests of Crankshafts

From "Tensile and Fatigue Tests of Drop Forged and Cast Crankshafts Provide Reliable Data for Design Engineers" in *Drop Forging Topics*, Vol. II, No. 3, 1947. Published by the Drop Forging Association, Cleveland 15, Ohio.

COMPARATIVE TESTS on drop forged and cast steel crankshafts, which were conducted by Lessells and Associates, Boston, Mass., as a phase of the research program of the Drop Forging Association, are summarized and made available for design calculations, including two charts. The chemical compositions of the nickel-chrome-molybdenum test specimens are given in the table. Some specimens were taken from cast steel keel blocks; others were cast.

The heat treatment of the forged crankshaft and an extension of it was as follows: Normalize at 1,650 deg F; oil quench from 1,550; draw at 1,225. After the test extensions had been removed, the crankshafts were finished (see Fig. 1) machined and nitrided prior to fatigue testing.

Heat treatment performed on the high carbon cast keel blocks and crankshafts was as follows: Normalized at 1,950 deg F and air cooled; normalized at 1,650 and air cooled; held at 1,230 for 10 hours; furnace cooled to 900 and cooled in air.

Low-carbon cast keel blocks and crankshafts were given the following heat treatment: Normalized at 1,950 deg F; oil quenched from 1,600; draw at 1,180 and air cooled. After heat treatment, the crankshafts were finished, machined and nitrided prior to fatigue testing.

Tensile tests and fatigue tests were:

1. Tensile tests on bars cut from the forged crankshaft extensions after heat treatment.
2. Fatigue tests on bars from the same material.
3. Fatigue tests on forged crankshafts after machining and nitriding.
4. Tensile tests on bars cut from the cheeks of forged crankshafts (See Fig. 1).
5. Tensile tests on bars cut from the cast keel blocks of the high and low carbon steels after heat treatment.
6. Fatigue tests on bars cut from the same material.
7. Fatigue tests on cast crankshafts after machining and nitriding.
8. Tensile tests on bars cut from the cheeks of the cast test crankshafts.

Among the conclusions proposed as a guide in the selection of materials in design are the following: The drop forged product offers tensile strength greater by 36 percent for design and calculating purposes. Uniformity of the tensile strengths of the test bars from the extensions of the drop forged crankshafts is noted, 130,000 lb. per sq. in. being indicated as an ultimate tensile strength for design purposes. Drop forged products and cast steel products offer about the same degree of uniformity of hardness. However, the forged product is tougher.

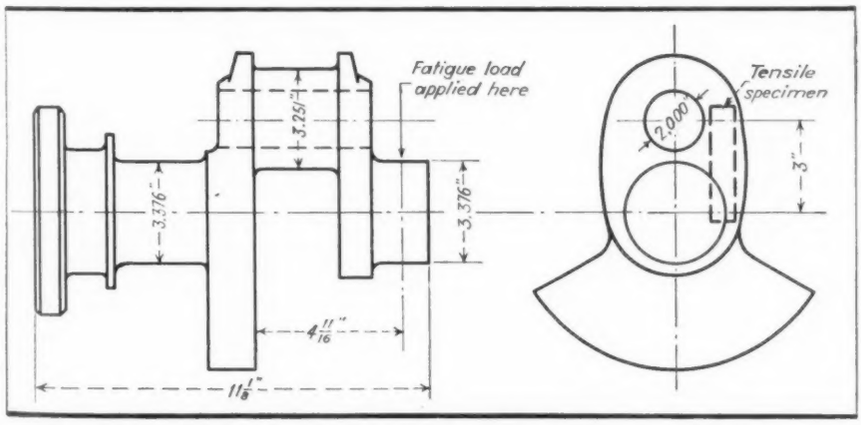


Fig. 1—Forged or cast steel crankshaft used for fatigue and tensile tests.

Chemical Analysis of Crankshaft Steels

Chemical element	Cast (high carbon), percent	Cast (low carbon), percent	Forged, percent
C	0.60	0.30	0.35
Mn	0.76	0.74	0.68
Si	0.43	0.28	0.24
Cr	1.10	1.07	1.01
Ni	0.57	0.71	0.84
Mo	1.00	0.99	0.96
Cu	0.81	0.41	nil
S	0.012	0.008	0.015
P	0.028	0.029	0.019

High Temperature Ceramic Coatings

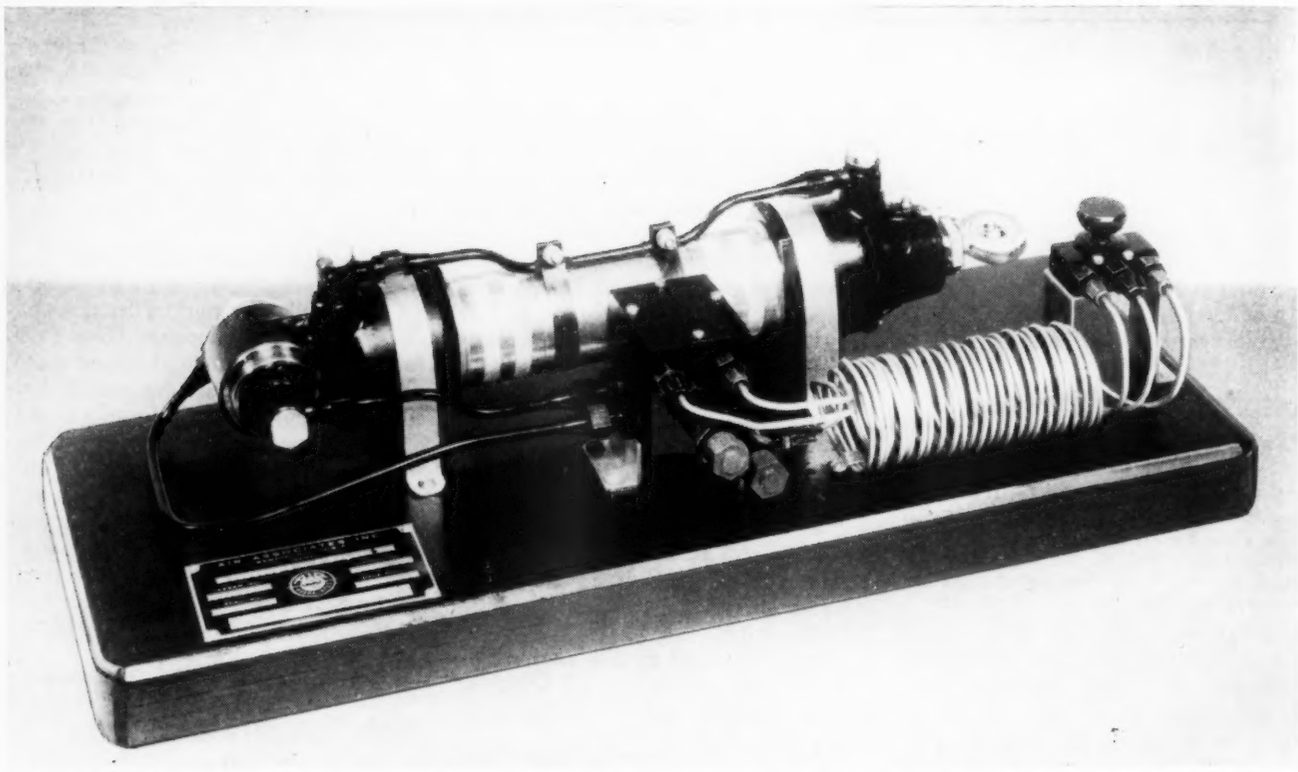
From "Ceramic Coatings for High-Temperature Protection of Steel," by W. N. Harrison, D. G. Moore and J. C. Richmond, *Journal of Research* of the National Bureau of Standards, March, 1947, p. 293.

A NEW TYPE of ceramic coating for the protection of low-carbon steel in high temperature service was developed during the war at the National Bureau of Standards and was used by the Army and Navy on the exhaust systems of certain aircraft and other vehicles. Outstanding features are:

1. High resistance to chipping under repeated thermal shock;
2. Protection of the metal against oxidation during prolonged exposure at temperatures up to about 1,250 deg. F.;
3. Freedom from the cracking and blistering produced in conventional porcelain enamels under comparable conditions of high temperature and severe temperature changes;
4. A mat surface which does not show highlights, and is useful when high visibility is not desirable.

To prepare these coatings, a mixture of a special grade of calcined aluminum oxide is used. The coatings can be used on low-carbon steel, and can be applied in thicknesses as low as 0.002 to 0.003 in., which is unprecedently thin.

Potential peacetime uses of these coatings include: (1) Domestic stove parts, such as grates or burners, (2) industrial furnace parts, such as mufflers, dampers, or burners, (3) parts for heat exchangers, (4) annealing boxes, and (5) mufflers and tail pipes for buses, trucks and automobiles.



An all-hydraulic remote control system used to control the action of a hydraulic cylinder. Control is self-energized.

Remote Hydraulic Control

An all-hydraulic control system for remote hydraulic valves. Operation is illustrated and explained. A cost and weight comparison is made with other systems.

HARRY P. KUPIEC
Air Associates, Inc.

A RECENTLY developed all-hydraulic control system, using a new method for the control of remote hydraulic valves, is lighter and lower in cost than many mechanical and electrical systems now in use. This all-hydraulic system may be used to control the flow of hydraulic fluid in lines of any capacity at pressures up to 3,000 psi and higher.

Valves used for the control of hydraulic systems are frequently installed at some point remote from the operator. Several actuating devices have been used to operate these valves such as: mechanical push-pull rods, flexible wire cables, electrical solenoids, and electric motors. For aircraft hydraulic systems, light-weight solenoids and also small light-weight electric motors, have been used.

However, even though the devices now in use are highly developed, they sometimes develop functional weaknesses. Mechanical linkages, bell-cranks and push-rods are difficult to install and to maintain. Flexible wire cables elongate under load and sometimes become inoperative. Electric solenoids and motors are costly, relatively heavy, and require the use of additional electrical equipment. The all-hydraulic system avoids the weak points found in other systems.

A schematic arrangement of an all-hydraulic control system is shown in Fig. 1(*A*); the main elements are the pilot valve and the remote control valve. Fig. 1(*B*) shows the schematic of the pilot valve and Fig. 1(*C*) shows the schematic of the remote control valve. If the control knob on the pilot valve is turned, the eccentric shaft (a) to which it is attached lifts one of the poppet valves (b) off its seat. Oil can then flow from one of the pilot valve lines through the pilot valve out into the waste line which is vented to the atmosphere. A reduction in pressure in the pilot valve line destroys the equilibrium of pressure in the remote valve. Pressure p_1 on face (f) of the main poppet valve drops below the supply pressure p_2 on face (g); consequently, the poppet valve is moved upwards and is forced off its seat. Oil can then flow through the valve. If the pilot valve is closed, equilibrium of pressure is quickly restored because oil can flow from the high pressure side of the poppet valve to the low pressure side through bleeder hole *d-e*. To control the operation of the hydraulic cylinder shown in Fig. 1(*A*), four poppet valves are used to obtain the proper operating

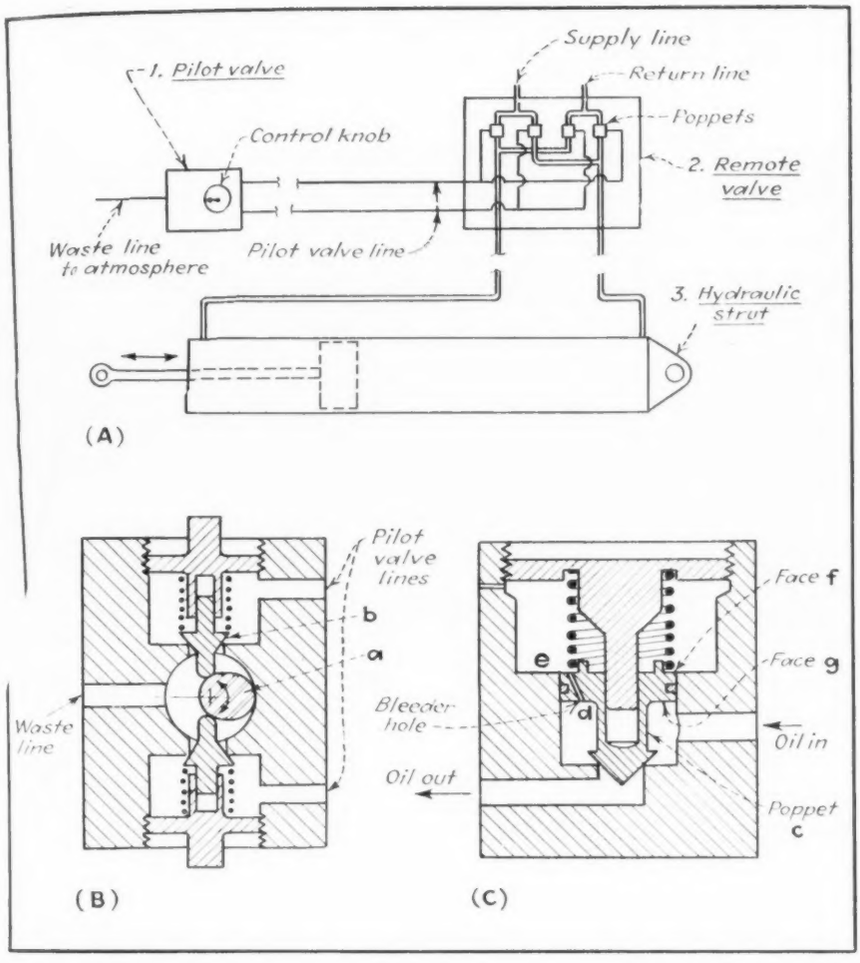


Fig. 1—*(A)* Schematic diagram of all-hydraulic remote control system. *(B)* Schematic diagram of pilot valve. *(C)* Schematic diagram of remote control valve.

characteristics; but only two lines are required to control the remote valve from the pilot valve. It is important to note that the response of the remote valve to the operation of the pilot valve is determined by the size of the pilot hole and the size of the bleeder hole *d-e*. If the pilot hole is larger than the bleeder hole, the differential pressure required for the operation of the main poppet is quickly built up. In practice the diameters of the pilot line and the bleeder line are small; therefore oil loss and power loss resulting from the operation of the pilot valve are low.

The system may be used in place of many of the well known systems for remote valve control. One application is the control of multi-purpose automatic machines. For this use the pilot valve is modified to incorporate a steel plunger operated by an external cam. Multiple set of units are used for sequencing operations or as safety switches.

The results of weight and cost studies of the all-hydraulic system compared to several other systems are shown in Figs. 2 and 3. On the basis of these studies, it appears that the designer can effect weight and cost savings by using all-hydraulic control systems for the flow of oil over a wide range of line capacities.

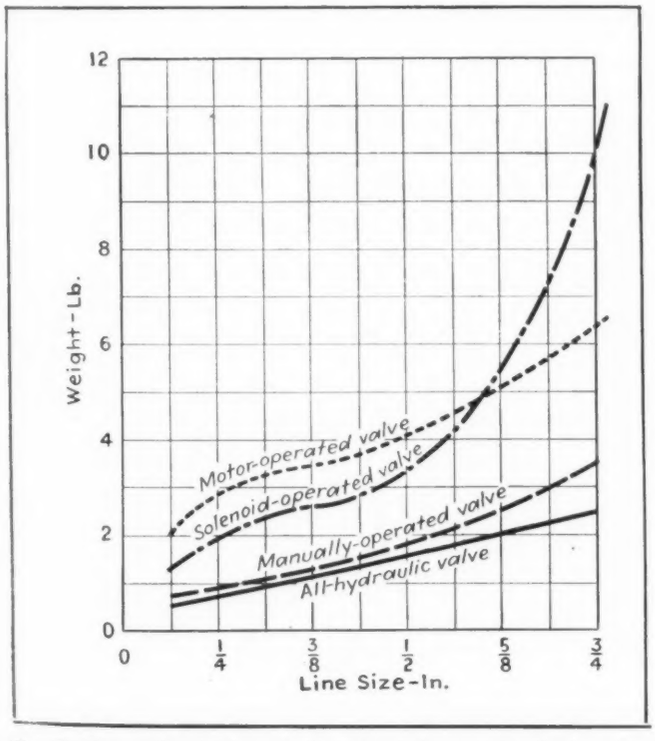


Fig. 2—Currently used control systems for remote hydraulic valves compared in terms of weight and supply line size.

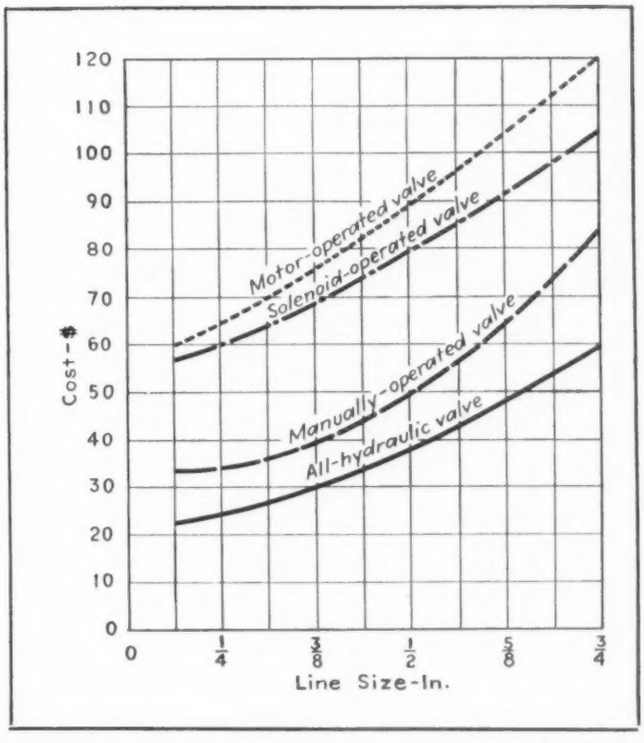


Fig. 3—Currently used control systems for remote hydraulic valves compared in terms of cost and supply line size.

Damping Characteristics of Dashpots

Mathematical equations for the relative velocities of piston to cylinder are developed for three cases; namely, a circular piston traveling coaxially in a circular cylinder, eccentrically in a circular cylinder and eccentrically in an elliptical cylinder. The test results, which are extensive, apply to a circular cylinder moving eccentrically in a circular cylinder.

JOHN B. PETERSON
National Bureau of Standards

DASHPOTS should be designed on the assumption that the piston will touch the side wall of the cylinder rather than move concentric to it. To attain consistent damping, the axis of the piston should run truly parallel to the axis of the cylinder. The coefficient of a dashpot varies with temperature mainly because of the variation in viscosity of the damping liquid. The percent change in viscosity of oils for a given change in temperature is usually less for low viscosity than for high viscosity oils.

These are some of the conclusions drawn from a technical study of dashpot design at the National Bureau of Standards. A mathematical analysis was verified experimentally. Although the dashpot is both an old mechanism and a simple one, consisting merely of a closely fitted piston in a cylinder filled with air or liquid, little is to be found in the technical literature about the design of dashpots.

The dashpot is a mechanical damping device for controlling rates of operation. Rate of motion of the piston relative to the cylinder, or the degree of damping action, is governed by the rate at which the cushioning medium, air or liquid, flows through the clearance area between the piston and the cylinder.

Since the equations suitable for design calculations define damping coefficients, they can be derived by the application of the common differential equation for damped vibrations of a system. The study is made for a liquid cushioning medium and its flow is assumed to be laminar. At high piston velocities, when turbulent flow exists, the experimental velocities were found to be much lower than those calculated on the basis of laminar flow. Let

R = One-half the sum of the radii of cylinder and piston;
C = radial clearance between piston and cylinder wall;
C_o = base clearance and the average radial clearance (see Fig. 1);
L = length of piston;
V = velocity of cylinder relative to piston;
V_o = observed velocity;
V_c = calculated velocity;
v' = velocity of fluid (relative to piston) at distance x from piston;
v = average velocity of fluid (relative to piston);
v_o = average calculated velocity of liquid in clearance;
P = difference in fluid pressure on two sides of piston;
Wg = force exerted on piston;
Q = volume flow per unit of circumference;
F = total volume flow;
ρ = density of liquid;
μ = coefficient of absolute viscosity.

In the theoretical treatment, the piston is held stationary and the cylinder is assumed to be moving upward. Thus in Fig. 1 the velocity of the liquid is shown relative to the piston. The differential equation for uniform motion is

$$\frac{d^2v'}{dx^2} = -\frac{P}{\mu L} \qquad (1)$$

from which

$$\frac{dv'}{dx} = -P/\mu L\,(x + B) \text{ and} \qquad (2)$$

$$v' = -P/\mu L\,(x^2/2 + Bx + D) \qquad (3)$$

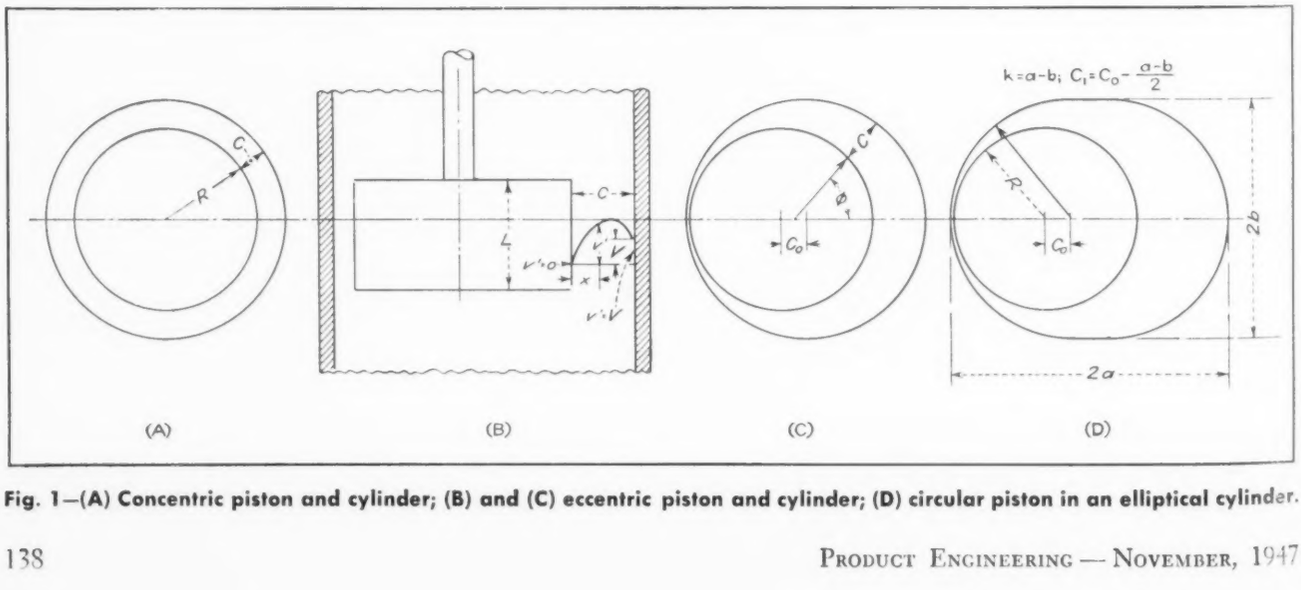


Fig. 1—(A) Concentric piston and cylinder; (B) and (C) eccentric piston and cylinder; (D) circular piston in an elliptical cylinder.

Where B and D are the constants of integration.

If v' is zero when x *is* zero, Fig. 1(*B*), then D is also zero. And if v' is V when x is C,

$$B = -\mu L V/PC - C/2 \quad (4)$$

Putting these valves of B and D in Equation (3) gives

$$v' = -\frac{Px^2}{2\mu L} + \frac{Vx}{C} + \frac{PCx}{2\mu L} \quad (5)$$

The volume of flow per unit of circumference is

$$Q = \int_0^C v'dx = PC^3/12\,\mu L + VC/2 \quad (6)$$

so that the average velocity across the clearance is

$$v = PC^2/12\,\mu L + V/2 \quad (7)$$

Case 1. Coaxial circular piston and circular cylinder. Since the average velocity of the liquid in the clearance times the area of the clearance equals the velocity of the piston times the cross sectional area of the cylinder,

$$\frac{V}{v} = \frac{2\pi RC}{\pi R^2} = \frac{2C}{R} \quad (8)$$

When v is eliminated between Equations (7) and (8)

$$V = \frac{PC^3}{6R\,\mu\,L} + \frac{VC}{R} \quad (9)$$

in which C represents the constant value of the clearance. Now

$$P = Wg/\pi R^2 \quad (10)$$

since Wg is the force exerted on the piston and πR^2 is the area of the piston. Substitute this value for P into Equation (9),

$$V = \frac{Wg}{6\pi\mu L}\left(\frac{C}{R}\right)^3\left(1+\frac{C}{R}\right) \quad (11)$$

For most design calculations the numerical value of C/R is small in comparison with unity so that Equation (11) can be simplified to

$$V = \frac{Wg}{6\pi\mu L}\left(\frac{C}{R}\right)^3 \quad (12)$$

Case 2. Circular piston rubs against the side wall of circular cylinder. The base radial clearance C_o is equal to the radius of the cylinder minus the radius of the piston. So long as the clearance C is small in comparison to the cylinder radius, C as a function of C_o and ϕ, Fig. 1(*C*) is expressed approximately by

$$C = C_o(1+\cos\phi) \quad (13)$$

Table I—Data on Pistons and Clearances

Piston	Material	Nominal diameter, in.	Length, in.	Radial clearance, in. in thousandths	
				Average value	Maximum variation
B-4	cast iron	2	0.25	2.08	±0.22
B-8	cast iron	2	0.50	2.04	±0.22
B-16	cast iron	2	1.00	2.18	±0.22
C-4	cast iron	2	0.25	5.09	±0.22
C-8	cast iron	2	0.50	5.09	±0.22
C-16	cast iron	2	1.00	5.16	±0.22
K-1	brass	1.25	0.054	1.38	±0.05
K-2	brass	1.25	0.116	1.38	±0.05
K-4	cast iron	1.25	0.25	1.38	±0.55
K-8	cast iron	1.25	0.50	1.38	±0.55
K-16	cast iron	1.25	1.00	1.38	±0.55
L-1	brass	1.25	0.057	4.33	±0.55
L-2	brass	1.25	0.113	4.33	±0.55
L-4	cast iron	1.25	0.25	4.33	±0.55
L-8	cast iron	1.25	0.50	4.33	±0.55
L-16	cast iron	1.25	1.00	4.33	±0.55

Table II—Viscosities and Densities of Four Damping Liquids

Damping liquid		Viscosity (poise)		Density (gram per cc)	
Trade name	Designation	at 24 deg. C.	at 27 deg. C.	at 24 deg. C.	at 27 deg. C.
Vacuum oil	V	0.00830	0.00794	0.733	0.770
Bayol D	B	0.0174	0.0165	0.784	0.782
Marcol	M	0.245	0.215	0.847	0.841
Marcol	N	0.215	0.188	0.836	0.831

Poises can be converted to lb. per sq. in. by multiplying by 5.6×10^{-3}; densities can be converted to lb. per cu. in. by multiplying by 0.03613.

This C is the actual clearance. Upon substitution into Equation (7) and dropping the $V/2$ term, the velocity across the clearance is

$$v = \frac{PC^2_o}{12\,\mu L}(1+\cos\phi)^2 \quad (14$$

The volume flow past the piston is now

$$F = \int_0^{2\pi} v\,CR\,d\phi = 5\,P\,\pi\,RC^3_o/12\,\mu\,L \quad (15)$$

To get the average velocity v_o, Equation (15) is divided by $2\pi RC$ giving

$$v_o = 5\,P\,C^2_o/24\,\mu\,L \quad (16)$$

Following the reasoning in the derivation of Equations (8) to (11), similar equations for Case 2 can be established. The resulting equation for the velocity of cylinder relative to piston is

$$V = \frac{5\,Wg}{12\,\pi\mu L}\left(\frac{C_o}{R}\right)^3 \quad (17)$$

Case 3. Circular piston in an elliptical cylinder. The piston is assumed to move in contact with an element along the major axis of the cylinder wall, Fig. 1(*D*) the equation for the velocity is

$$V = \frac{Wg}{12\,\pi\mu L}\left(\frac{C_1}{R}\right)^3\left(5+\frac{45k}{4C_1}+\frac{39k^2}{4C_1^2}\right) \quad (18)$$

The quantities k and C_1 are defined in Fig. 1(*D*). Credit for the solution of Case 3 is given to Dr. G. H. Keulegan.

Experimental Verification

Experiments show that the piston normally moves eccentric to the cylinder. The pistons tested were 1.25 and 2 in. in diameter, 0.062 to 1.00 in. long, and the clearances varied from 0.00138 to 0.00516 in., Table I. The difference in pressure on the two sides varied from about 2 to

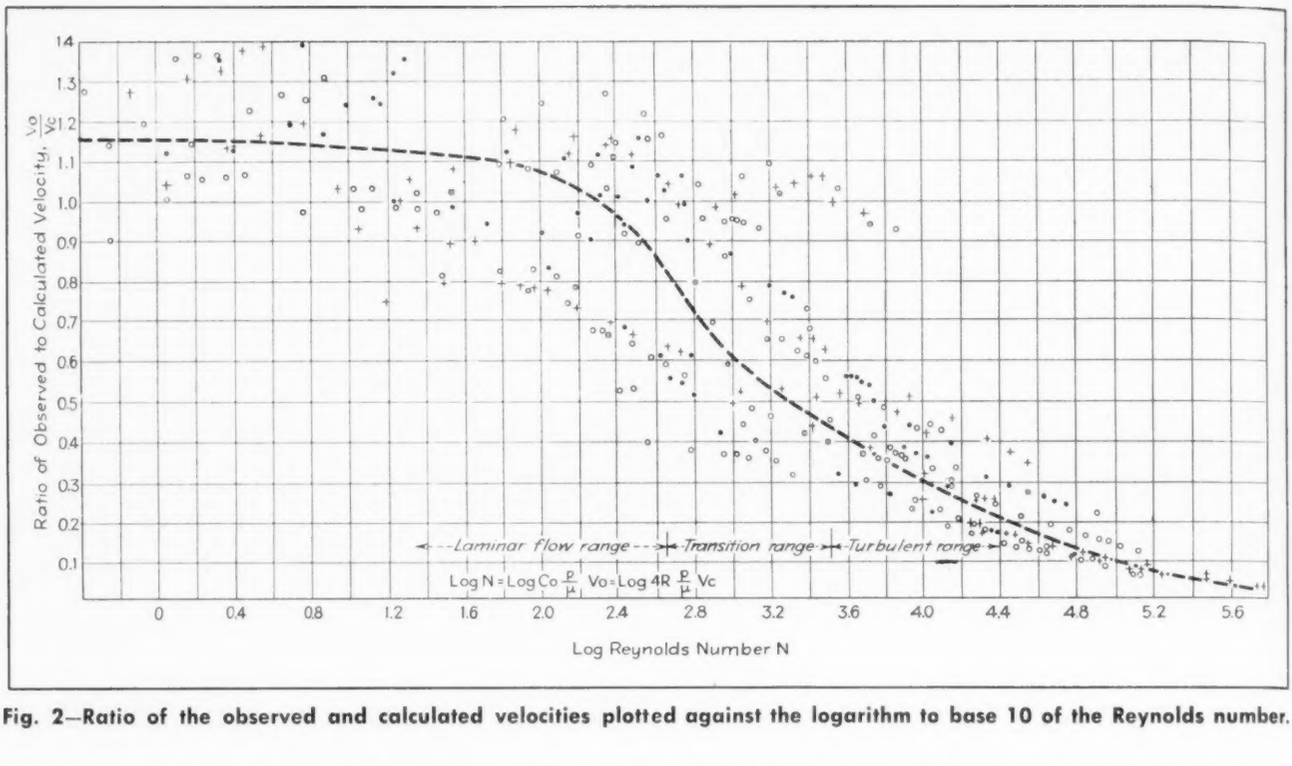

Ratio of Observed to Calculated Velocity, Vo/Vc
Log Reynolds Number N
Laminar flow range
Transition range
Turbulent range
Log N = Log Co ρ/μ Vo = Log 4R ρ/μ Vc

Fig. 2—Ratio of the observed and calculated velocities plotted against the logarithm to base 10 of the Reynolds number.

65 lb. per sq. in. Piston velocities for each assembly were measured in four damping liquids of three different viscosities.

Absolute viscosities and densities of the liquids at 24 and 27 deg. C. are given in Table II. When the temperatures at which the experiments were run differed slightly from these temperatures, viscosities and densities for the actual temperatures were interpolated linearly.

Reynolds number, designated by N to avoid confusion with radius R, is given by

$$N = C_o \rho V_o/\mu = 4\, R\rho V_c/\mu \qquad (19)$$

At low velocities, Fig. 2, most of the observed velocities agree fairly well with the eccentric piston analysis, Case 2. Theoretically, the piston velocity is 2.5 times greater in Case 2, the eccentric position, than in Case 1, the coaxial position.

Although a travel of 16 in. was available on the test apparatus, a distance of 6 in. or less was used in measuring the observed velocities. Travel through the center section of the cylinder was always timed. The piston was allowed to come to a constant speed before the timing interval started, so as to eliminate any inertia effects.

To get consistent results the axis of the cylinder and piston had to be kept parallel. This was done with the two sets of adjustment screws at the top of the cylinder. The cylinder position was always adjusted to obtain maximum velocity of the piston for a given load. One quarter turn in one of these screws made an appreciable difference in the velocity, especially for the long pistons.

Several of the tests gave curves of questionable shape. These tests were repeated as many as four times, each time with practically the same results. Such tests were repeated with pistons with sharp edges and with edges rounded to a radius of 0.005 in. Rounding the edges had practically no effect on the test results. The repeat tests also indicated that the variation was not the result of any chance adjustment or relative alignment of the piston and cylinder.

The foregoing equations were derived on the assumption that there was no turbulence. As noted in Fig. 2 the disagreement between the observed and calculated values is greatest in the turbulent range. An empirical equation that was found to fit the average test results is as follows:

$$V = \frac{5\,W_g}{12\,\pi\mu L}\left(\frac{C_o}{R}\right)^3 \times 4\,R\phi\left[\frac{\rho}{\mu}\frac{5\,W_g}{12\,\pi\mu L}\left(\frac{C_o}{R}\right)^3\right] \qquad (20)$$

in which the Reynolds number factor

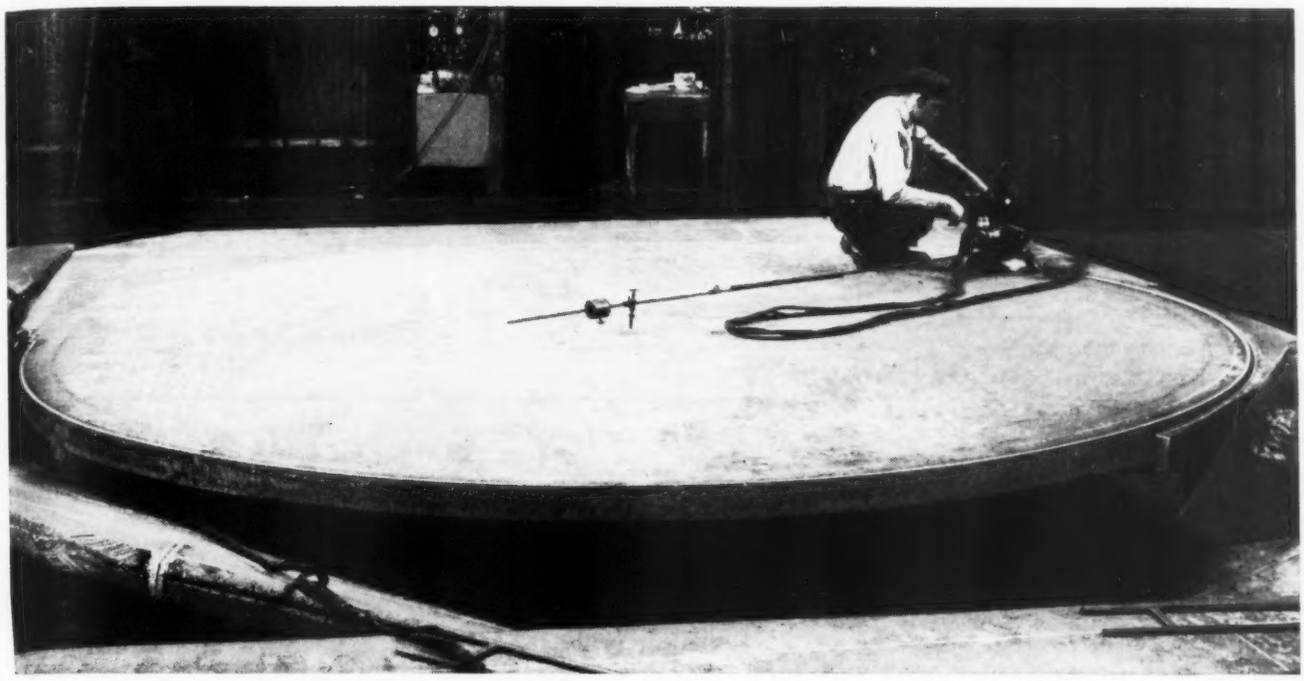
$$\phi\left[4\,R\frac{\rho}{\mu}\frac{5\,W_g}{12\,\pi\mu L}\left(\frac{C_o}{R}\right)^3\right] = \phi\,(4\,R\rho V_c/\mu) = V_o/V_c \qquad (21)$$

The ratio V_o/V_c can be taken from the average curve of Fig. 2, which is shown dotted.

According to Equation (20), the force necessary to cause a given velocity varies directly as the length of the piston and inversely as the cube of the radial clearance. The tests indicate that, except for errors of observation, these relations hold for both the laminar and the turbulent ranges, for any piston in the series tested. They would not hold for thin pistons. In the laminar range the force, for a given velocity, varies directly as the cube of the radius of the piston. In the turbulent range this relation is more complicated.

* * * *

IN MESOPOTAMIA, 5,000 B.C., a new kind of writing instrument was invented. It was a long, hollow reed with a built-in ink reservoir. The ink fed slowly from the reservoir to a tiny hole in the point. This "fountain pen" was designed to write for a long time, but ———————— it would not write under water!



Flame cutting a circle from a large rolled steel plate. Five of these circles are used to make up one disk flywheel.

Flame-Cut Disk Flywheels

Strength, kinetic energy, weight and cost as compared to cast spoke type wheels. Article developed in cooperation with engineers of Lukens Steel Company, Coatesville, Pa.

WITHIN the last fifteen years, the flame-cut disk flywheel has largely displaced the rim-and-arm type flywheel. As a result of the development of facilities for production of large rolled steel plates and the development of the flame cutting technique, manufacturing costs have been lowered to such an extent that disk flywheels are actually more economical than cast rim-and-arm type flywheels. Coupled with economy of production are other factors that favor the disk flywheel such as less weight, smaller diameter, higher permissible rim speeds, improved balance and stability, and higher real margins of safety.

From the designers standpoint, the trend towards the use of disk flywheels is gratifying. The strength of a disk flywheel can be determined accurately by standard design formulas. On the other hand, although design formulas exist for rim-and-arm type flywheels, the behavior of these flywheels in service has been so erratic that the efforts of the designer to calculate strength are of little avail.

Rim-and-Arm Type Flywheels

The maximum allowable rpm of a flywheel is reached when the stresses developed by the centrifugal forces equal the allowable stresses of the material used. In the rim-and-arm wheel, in addition to the tangential bursting stresses, there are stresses developed by bending moments. Each section of the rim is in effect a uniform loaded curved beam with fixed end restraints at the points of attachment of the arms to the rim.

Thus, tensile stresses caused by bending must be added to the tangential stresses in the rim. The abrupt change in rim cross-section at the point of attachment of the arms plus the radial tension in the arms cause stress concentration. On account of the complex stress pattern, it is not safe to depend on the calculated stresses; therefore a high factor of safety must be used. Obviously, then, to calculate the stresses using precise formulas (see Timoshenko's "Strength of Materials," page 98, Vol II, 2nd Edition, 1947) only to superimpose a large margin of ignorance, is not good design practice.

Extensive tests on flywheels and rotating members in which the specimens were whirled at increasing speed until they burst have established the fact that the bursting speeds cannot be calculated by any formulas with any degree of accuracy except for disks of uniform thickness.

As a design expedient, the empirical rule generally used in the design of rim-and-arm type flywheels is to calculate the tangential stress by the formula

$$s = v^2/10$$

where v = rim speed in ft. per sec.

Using this formula and assuming values of allowable stress of 3,100 psi for flywheels not subjected to shock loads and 950 psi for wheels subjected to shock, conservative allowable max-

imum speeds are obtained. These allowable speeds are below the speeds at which cast iron wheels have failed in service.

Disk Type Fywheels

A disk type flywheel flame cut from a steel plate is inherently stronger than the rim-and-arm type. There are no abrupt changes in cross-section and there are no bending stresses. The stresses in a rotating disk can be calculated with a great degree of accuracy. Another factor is the greater uniformity of the material in a rolled steel disk compared to an iron casting. In the design of a disk type steel flywheel the allowable stress is usually taken as 12,000 psi for steady load operation and 5,000 psi for shock conditions, as in flywheels for heavy presses. For designs in which the material has been carefully selected and there are no sudden changes in flywheel speed, it has been well established that the allowable stress can be taken as one-half the yield stress of the material.

The old Stodola formula for stresses in rotating disks gives the maximum tangential stress developed. A convenient form of this equation is given by R. J. Roark on page 312 of his book, "Formulas for Stresses and Strain." This equation gives the maximum tangential stress developed, which occurs at the surface of the bore. For convenience, the equation is given here:

$$\text{Max } S_t = \frac{1}{4}\,\frac{\delta\omega_1^2}{386.4}\,[(3+\nu)R^2 + (1-\nu)R_o^2] \qquad (1)$$

where

δ = density—lb./cu. in.
R = radius—in.
R_o = radius of bore—in.
ω_1 = speed in rad./sec.
$\nu = 1/m$ = Poisson's ratio

Tests on rotating disks have established the accuracy of this formula to be within five to ten percent. Such tests have also proved that by overspeeding the disk to a point where the maximum stresses developed are beyond the proportional limit of the material but below its ultimate stress, residual stresses are established when the disk is stopped. When the disk is again rotated the residual or prestresses result in a lowering of the maximum allowable operating stresses produced before overspeeding. Thus the maximum allowable operating speed of the rotating part is increased. A terse explanation of this with charts of the stress distribution is presented in the paper "Improved Engine Parts by Direct Measurement of Strain" by R. G. Anderson of the Cleveland Research and Development Laboratories of the Aluminum Company of America. The paper was published in the September 1946 number of the SAE Journal. It explains why aluminum disks can be whirled at rim speeds up to 2,400 ft per sec without bursting, although the calculated stress at this speed is beyond the ultimate strength of the material.

Because of the higher allowable rim speed of a rotating disk of uniform thickness, such a type of flywheel will be smaller and weigh less than a cast rim-and-arm type wheel of the same effectiveness. Conservatively, the rolled steel disk type wheel can be run at a rim speed at least twice as fast as the rim-and-arm type wheel.

In the design of any flywheel, the basic requirement is that the wheel shall deliver a certain minimum amount of energy upon a specified allowable drop in speed. If the normal running speed is ω_1 rad/sec and the minimum allowable speed is ω_2 rad/sec, the energy, ΔE, delivered

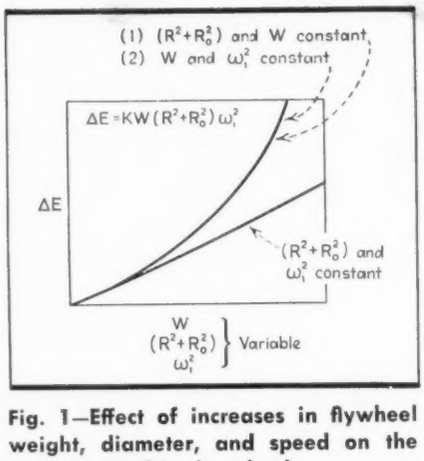


Fig. 1—Effect of increases in flywheel weight, diameter, and speed on the energy stored in the wheel.

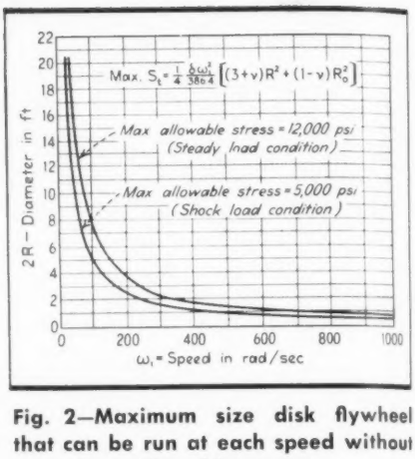
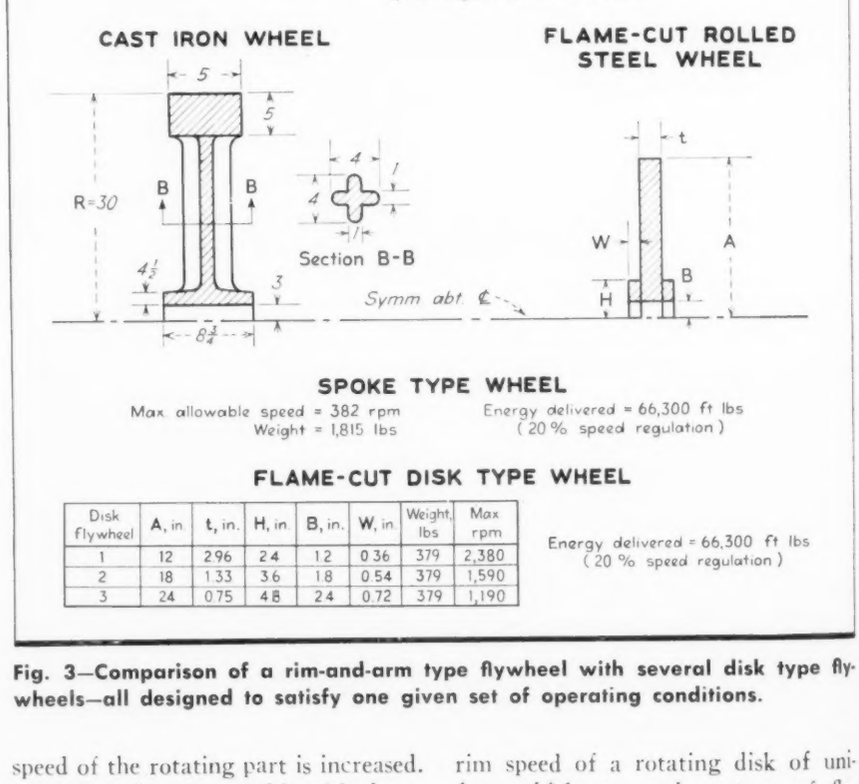

Max. $S_t = \frac{1}{4}\frac{\delta\omega_1^2}{386.4}[(3+\nu)R^2 + (1-\nu)R_o^2]$
Max allowable stress = 12,000 psi (Steady load condition)
Max allowable stress = 5,000 psi (Shock load condition)
2R — Diameter in ft
ω_1 = Speed in rad/sec

Fig. 2—Maximum size disk flywheel that can be run at each speed without exceeding allowable stresses.


Operating Conditions: ΔE, Energy to be delivered = 66,300 ft lbs
Speed regulation = 20 percent
CAST IRON WHEEL
FLAME-CUT ROLLED STEEL WHEEL
R=30
Section B-B
Symm abt.
SPOKE TYPE WHEEL
Max. allowable speed = 382 rpm
Weight = 1,815 lbs
Energy delivered = 66,300 ft lbs
(20 % speed regulation)
FLAME-CUT DISK TYPE WHEEL
Energy delivered = 66,300 ft lbs
(20 % speed regulation)

Disk flywheel	A, in.	t, in.	H, in.	B, in.	W, in.	Weight, lbs	Max rpm
1	12	2.96	2.4	1.2	0.36	379	2,380
2	18	1.33	3.6	1.8	0.54	379	1,590
3	24	0.75	4.8	2.4	0.72	379	1,190

Fig. 3—Comparison of a rim-and-arm type flywheel with several disk type flywheels—all designed to satisfy one given set of operating conditions.

by the wheel in decelerating from ω_1 to ω_2 in unit time is

$$\Delta E = 1/2 \frac{W}{g} \rho^2(\omega_1^2 - \omega_2^2)$$

where

W = weight of wheel in lb.
g = acceleration due to gravity = 32.2 ft./sec.^{2}
ρ = radius of gyration in ft.
$\omega_1 - \omega_2$ = speed fluctuation

The radius of gyration, ρ, for a disk of uniform thickness with a hole in the center is

$$\left(\frac{R^2 + R_o^2}{2}\right)^{1/2}$$

where

R = outside radius in ft.
R_o = radius of the bore in ft.

Hence, if ω_2 is written as $C\omega_1$, where C* is a fraction

$$\Delta E = 1/2 \frac{W}{g} \frac{(R^2 + R_o^2)}{2} \omega_1^2 (1 - C^2)$$

$$\Delta E = KW (R^2 + R_o^2) \omega_1^2$$

where K is constant

* The value of C depends upon the machine to which the flywheel is fitted, and the machine loads.

The relative effect of each variable W, R and ω_1 on ΔE is shown in Fig. 1. Obviously ΔE is increased to a greater extent by increasing R or ω_1 rather than the flywheel weight W. However, the values of R and ω_1 are interrelated and limited by the allowable tangential stress developed. By reference to Equation (1), it can be seen that the tangential stress is proportional to $\omega_1^2 R^2$. Curves defining the maximum size flywheel that can be run at each speed without exceeding the safe allowable stress of 12,000 psi or the safe shock stress of 5,000 psi are shown in Fig. 2.

Flywheels Compared

The superiority of the disk flywheel over the rim-and-arm type flywheel is illustrated strikingly by the designs shown in Fig. 3. Each flywheel was designed to fit the same set of operating conditions. The design of the rim-and-arm type wheel followed conventional design practice in that the following assumptions were made.

1. Rim weight is 66 percent of total weight.

2. For energy calculations, 1/3 of the spoke and hub weight is considered as additional rim weight.

3. The radius of gyration is 90 percent of the outside radius.

Each flywheel was designed to work at the maximum normal running speed at which the working stresses are equal to the allowable stresses. In addition, each flywheel was designed to supply the same energy at the same percent speed regulation. On this basis, the disk flywheels shown can be run at speeds 3 to 6 times the speed of the rim-and-arm wheel because of their greater strength and smaller size. At the same time, the weight of each disk wheel is less than one-quarter that of the rim-and-arm wheel. In practice, limitations on normal running speeds would reduce these ratios. At lower normal running speeds, the weight of the disk wheel is increased, but, at the same time, the real factor of safety is also increased, because the actual tangential and radial stresses are reduced.

The advantages to be gained through the use of light disk flywheels run at high speeds extend to other parts of the machine fitted with this type of wheel. As a direct effect, shaft size and flywheel bearing size are reduced; the flywheel housing is smaller and the machine frame design is improved. The sum total of the changes brought about by reducing the flywheel size and weight results in a compact, economical machine of improved appearance. Consequently, for the last ten years or more many machines such as power presses, press brakes, turbogenerators have been equipped with disk flywheels.

Two common designs for disk flywheels are shown in Fig. 4. Here the effectiveness of the disk flywheel is improved further by making the rim thicker than the web. In this way a greater percentage of the flywheel weight is concentrated in the rim and the radius of gyration is increased. The energy that can then be stored in these flywheels at a given speed will be greater than the energy stored in a disk flywheel of constant thickness having the same weight and outside diameter.

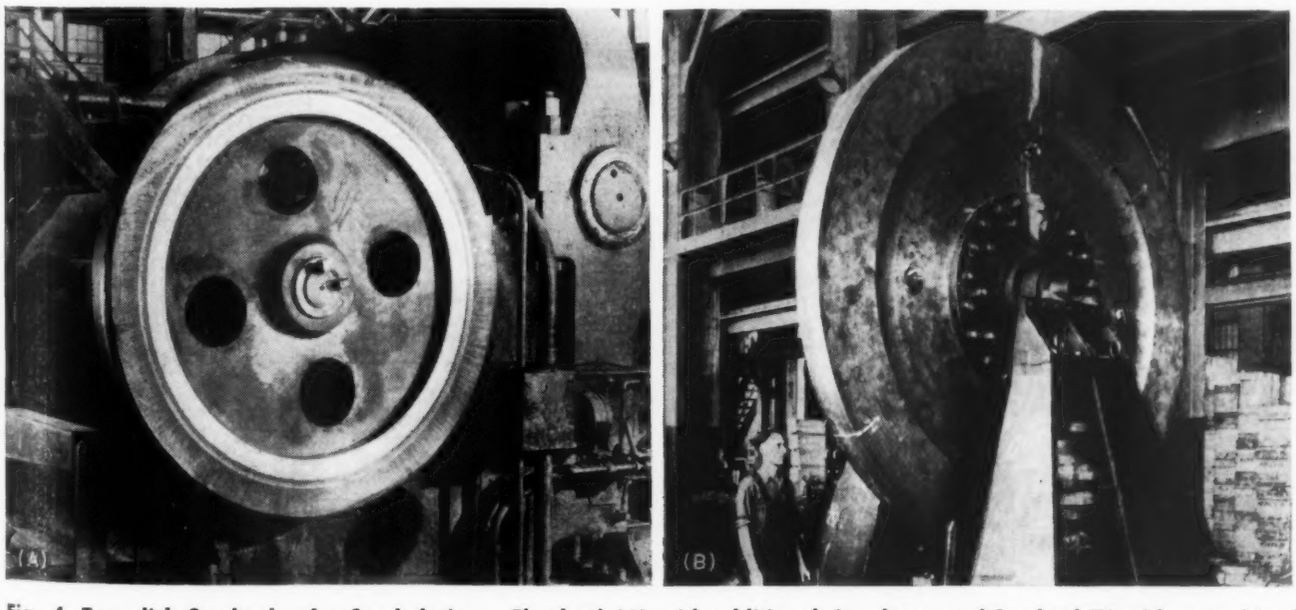


Fig. 4—Two disk flywheels of refined design. Flywheel (A) with additional rim plates, and flywheel (B) with a machined center are more effective than a disk flywheel of uniform thickness, storing more energy with less weight.

TECHNICAL NEWS HIGHLIGHTS

ECPD Raises Professional Standards of the Engineer

EMBARKING ON A POSTWAR COURSE of intensified service, the Engineers' Council for Professional Development recently issued a report summarizing its fifteen years of activity, and its plans for the future. A new and significant phase of engineering progress came into being in 1932 with the formation of the ECPD, sponsored by the principal national societies of the engineering profession as a cooperative movement for improving the selection, education, post-college training, and methods of recognizing attainment of engineers.

Chartered as "a conference body organized to enhance the professional status of the engineer", the Engineers' Council for Professional Development is a co-operative agency with eight constituent organizations. The council of 24 members, three from each of the participating societies, has been envisioned as the nucleus in a mass movement of the engineering profession toward self-betterment. ECPD collects and, through its participating societies, disseminates information concerning the best ways to advance this movement. Since its formation 15 years ago, the ECPD has focussed attention on the development of the individual engineer and has tried to correlate factors contributing to the cultural and technical sides of professional development.

Basic Program

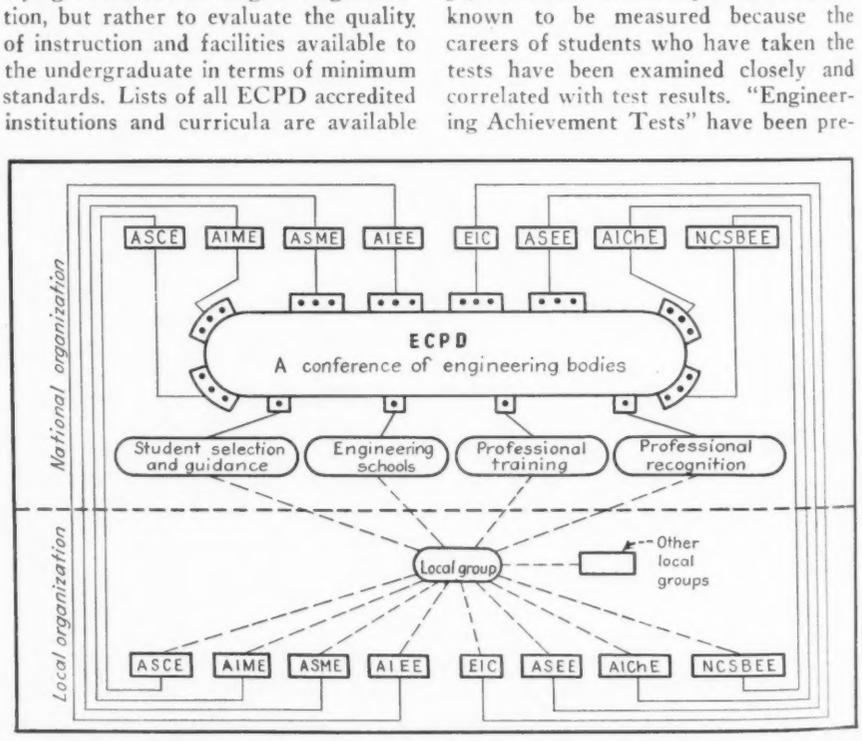
To achieve a system in which the progress of the young engineer can be recognized by the public, by the profession and by the engineer himself, ECPD has divided its basic program into four interrelated phases. The first is a study of the process through which interested young men and women can be guided to engineering careers. It is at this early point that those who do not show promise of successful engineering careers should be dissuaded from going further. The second phase has to do with co-operation between the practicing profession and engineering schools. At the present time this phase is largely occupied with a program of evaluation for accrediting curricula leading to engineering degrees. The third phase is concerned with the development of appropriate post-college training programs through which the young engineer can keep up with rapidly moving technical developments. The final phase is aimed at creating an effective correlation among the various criteria indicating professional development of the individual engineer.

Curricula Evaluated

As of October 1946, 580 curricula had been inspected, evaluated and accredited at 133 of the 167 American institutions that grant engineering degrees; and 98 curricula had been inspected but not accredited. ECPD is not trying to standardize engineering education, but rather to evaluate the quality of instruction and facilities available to the undergraduate in terms of minimum standards. Lists of all ECPD accredited institutions and curricula are available to any interested persons or agencies, and are used as the basis for the educational requirements for legal registration by the various state boards. ECPD's examination of curricula for accrediting purposes is undertaken only at the invitation of the institution.

Selection and Guidance Tests

To arrive at standards for selecting and guiding engineering students, ECPD joined forces with the American Society for Engineering Education and the Carnegie Foundation for the Advancement of Teaching. This combined group arrived at a set of tests collectively called the "Pre-Engineering Inventory" which are used to determine the qualifications of prospective students. The tests were validated and refined by presenting them to about 36,000 individuals. Proper abilities are known to be measured because the careers of students who have taken the tests have been examined closely and correlated with test results. "Engineering Achievement Tests" have been pre-



Interrelation of ECPD and its participating societies, on local and national levels.

pared, and are now in usable form, to check the progress of students in their sophomore year. ECPD has also begun work on a series of tests to measure student achievement at the time of graduation. These tests will provide useful information to the students and to engineering schools. The students will know if they are aiming at the right career and can check their progress, and the schools can determine what changes, if any, should be made in their engineering curricula.

Future Need for Engineers

Recent surveys by the ASEE have indicated the future annual need for new engineers to be 17 percent of current employment. In connection with this survey and with statistics released by the U. S. Labor Department, the ASEE has estimated a need for 90,000 engineering graduates between 1946 and 1950. On the basis of these figures, in 1950 about 46 percent of all engineers will have entered the profession within the ten-year period 1940-1950, and about 27 percent during 1946-1950. This situation offers a special challenge to the ECPD Committees on Engineering Training and Professional Recognition. With such a large percentage of neophytes in the engineering profession, ECPD feels that well co-ordinated programs of counseling, gundance and indoctrination will be essential for the best interests of all concerned.

On the basis of estimates made by the ASEE, the deficit of engineering graduates will have been wiped out by 1952. The need for continuing engineering education at an overload level therefore will lessen beginning with the entering freshman class of 1949. However, ECPD warns that future economic and political developments may have a marked effect on supply and demand of technical personnel.

Plans for the Future

ECPD plans for the future consist of 20 main activities to be carried out by the four standing committees.

COMMITTEE ON STUDENT SELECTION AND GUIDANCE:

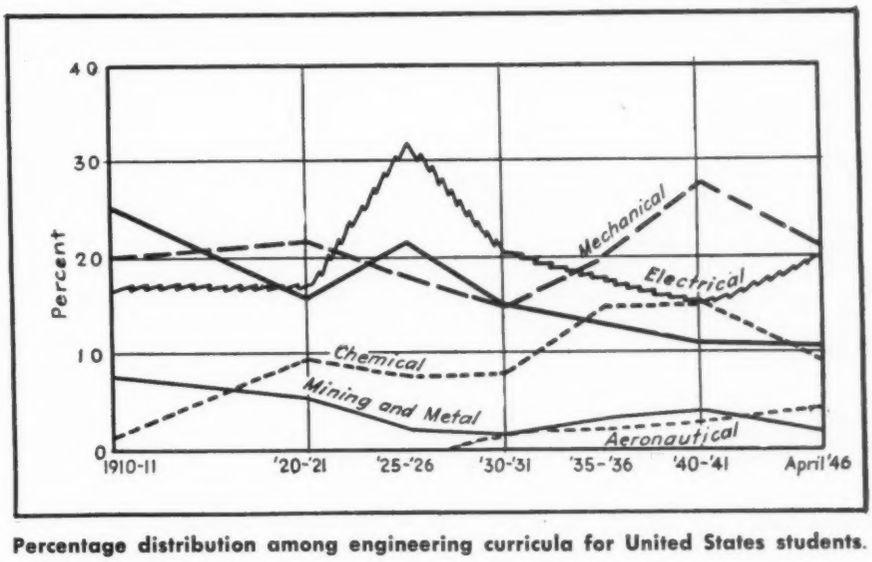
1. Supplying information to potential students concerning the qualifications essential for success in engineering.
2. The preparation and continuing administration of examination designed to determine the aptitudes of students who are considering engineering studies.
3. Continuing assistance to the local groups that guide high school students in the college curricula.
4. The guidance of engineering students in the selection of those engineering courses best suited to their individual talents.
5. Stimulation of a more active participation of the local organizations of ECPD's constituent societies in the active promotion of ECPD objectives at the community level.

COMMITTEE ON ENGINEERING SCHOOLS:

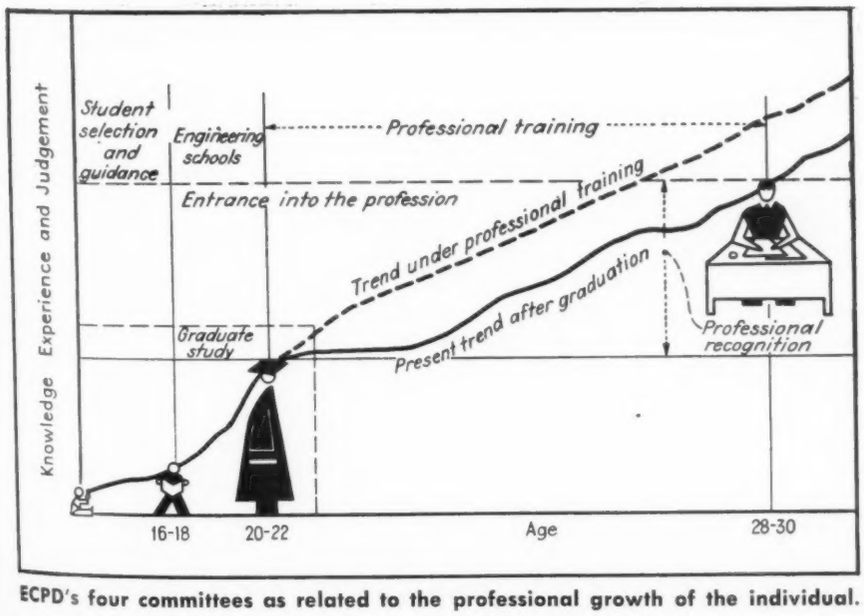
1. The examination and evaluation of new engineering curricula.
2. Extension of the accrediting program to include Canadian engineering schools, in cooperation with the EIC.
3. The reinspection and re-evaluation of previously accredited undergraduate engineering curricula, to guarantee that minimum standards are being currently met.
4. The inspection and evaluation of graduate engineering courses.
5. The development of tests to measure a student's academic accomplishments in engineering college and the investigation of other traits which contribute to success in engineering.
6. Cooperation with South American engineering colleges for the purpose of establishing an accrediting program for their institutions.

COMMITTEE ON PROFESSIONAL TRAINING:

1. The stimulation of post-college training programs within industry that will correlate the interests of engineers with those of management.
2. Encouragement of young engineers to complete the requirements for an engineering license; stimulation of an individual study program to aid the young graduate to avoid the after-college slump in technical development.
3. The preparation and distribution of an ECPD "Manual for Junior Engi-



Percentage distribution among engineering curricula for United States students.



ECPD's four committees as related to the professional growth of the individual.

neers", which is intended to serve as a guide following graduation.

4. The encouragement of young engineers to participate in the activities of the local sections of the national engineering societies.

COMMITTEE ON PROFESSIONAL RECOGNITION:

1. Development and promulgation of clear definitions of the function of each type of professional engineer, and the maintenance of a clear distinction between professional and non-professional services.

2. The development of a better understanding of the role of the engineer in modern society, and the promotion of a healthy pride in engineering achievements among engineers themselves.

3. The development of methods whereby ECPD can help engineers become an arm of management in industry, to improve labor relations and productivity.

4. The development of a professional consciousness among engineers, engineering teachers and engineering students.

5. The working out of a detailed program for professional unity. The promotion of uniform membership grades and nomenclature in the national engineering societies. Study the possible need for an over-all engineering society or federation.

The plans of the four standing committees require considerable expansion in both the extent and intensity of ECPD activities if they are to be carried out successfully. These activities already have exceeded the capacity of volunteer service alone and must be supplemented by the active interest of more individual members of engineering societies in both Canada and the United States.

SAE Plans Standardization of Automotive Drafting Practice

PREPARATION OF A MANUAL LEADING to standardization of drafting practices in the automotive industries has been undertaken by the Society of Automotive Engineers. The project is directed by SAE Technical Board, with D. G. Roos, of Willys-Overland Motors, Inc., Toledo, Ohio, as sponsor. It will be developed by a Steering Committee of 15, with W. A. Siler, of Delco-Remy Div., General Motors Corp., Anderson, Ind., as chairman.

Need for uniformity became apparent during the war. Manufacturers discovered that drafting practices differed widely not only between companies and industries, but also between company divisions and plant departments, with resulting delays, difficulties, and misunderstandings. Several companies have become directly interested in the SAE project and have created drafting manual committees within their own organizations for purposes of coordination with SAE groups. It is expected that, having developed automotive practices, SAE will be in position to cooperate with other groups for unification and standardization on a nationwide basis.

Basically, the new manual will be patterned after the SAE Aeronautical Drafting Manual which, during the war and subsequently, demonstrated the advantages of uniformity especially in cases involving interlocking of engineering and production techniques in departments, divisions, companies, industries, and the various branches of the military. The 15 subcommittees will develop different phases of the project and later will coordinate their work so that the manual uniformly may cover the entire field. The subcommittees will be responsible for size and format; editorial work; line conventions, lettering, and sectioning; projection and development, dimensioning; abbreviations, definitions, notes, and symbols; threads; gears, splines, and serrations; forgings, castings; small stampings; finish designations on drawings; springs; bodies; chassis frames.

Members of the Steering Committee will function as chairmen of sub-committees which jointly will prepare the manual. Upon publication as the SAE Standard Automotive Drafting Manual, the data will be made available to the passenger car, truck, bus, engine, tractor, body, equipment, electrical, accessory, and other automotive industries, as well as to engineering schools.

New Equipment Shown at Rail Manufacturers Exhibit

TEN THOUSAND LEADING RAILROAD OFFICIALS of the United States and many foreign countries attended the recent exhibit-convention of the Railway Supply Manufacturers Association held in Atlantic City, N. J. Norman C. Naylor, president of the RSMA said that more than ten million dollars worth of new raliroad equipment were displayed at the exhibit, the first of its kind since 1937. More than 260 leading manufacturers who supply domestic and foreign railroads were represented in the exhibit hall and at 3,000 feet of track exhibit space a short distance from Convention Hall.

The RSMA exhibit-convention was held in conjunction with meetings of the Purchases and Stores and Mechanical Divisions of the Association of American Railroads.

Innovations that pointed to improved comfort and convenience for rail travelers were graphically displayed in Convention Hall and at the track exhibit. Much emphasis was placed on improved railroad safety devices. For example, two-way radio-telephone for train crews and key mainline points were shown. Other new types of day coaches and grill-lounge cars which incorporate radically new systems of lighting and vanity lounges were on display.

New shock absorbers for freight cars, new signal equipment, switches and rails play an important part in the exhibit section that indicated a new era of development in metals for railroad use. Modern diesel-electric locomotives were shown at the track area less than a mile from Convention Hall. Other new locomotives, ranging from the small 44-ton switching locomotives to huge 6000 horsepower diesel-electrics were at the track exhibit, along with new models of sleeping cars and freight cars.

Fatigue-Testing Expert Given Templin Award by ASTM

FRANK B. QUINLAN, section leader in the Schenectady Works Laboratory of the General Electric Company and developer of an unusual pneumatic fatigue testing machine, has been awarded the Richard L. Templin award by the American Society of Testing Materials. The award, which is made annually by the ASTM to stimulate research in development of testing methods and apparatus, and to encourage the presentation of papers describing testing procedure and equipment, was made to Quinlin because of his outstanding contributions to science in that field.

The pneumatic fatigue tester is a device which, operating on an entirely different principal than any other fatigue machine, vibrates a test piece of metal between two streams of air so rapidly that results and data on fatigue strength, can be obtained in a much shorter time than by conventional methods. Operating on the principal of a resonant air column, it permits adjusting the stream of air to coincide with the natural frequencies of the metal under test. Using this device, it is possible to make tests at temperatures up to 1700 deg. F.

WASHINGTON NOTES

Atomic Patent Policy Approved by Advisory Panel

The patent policy of the Atomic Energy Act and the patent practice of the Atomic Energy Commission have been endorsed by AEC's Patent Advisory Panel. The panel, appointed to survey the patent procedures which AEC inherited from the Manhattan District, was made up of former patent commissioner Casper Ooms; William H. Davis, chairman of the Commerce Department's Patent Survey Committee; John A. Dienner, former president of the American Patent Law Association; and Hector M. Holmes, Boston attorney.

Patent policy in atomic matters has been controversial ever since the end of the war. Over the protests of most of industry, the Atomic Energy Act modifies and in part eliminates the patent system, on atomic matters. The panel, however, insists that this step was a natural consequence of the law's policy of putting atomic development—in its early stages at least—under complete government control.

Under the act, patents concerning production of fissionable material such as Uranium 235 or plutonium, and production of atomic weapons, are eliminated. Existing patents on devices useful solely for these purposes are cancelled, and no new ones will be issued. Patents valid in other fields do not apply to the atomic energy field.

As to non-military applications of atomic energy, the law is designed to prevent patents from having any restrictive effect. AEC may requisition any discovery or patent in this field. Alternatively, it may declare such a patent "in the public interest" and require that it be licensed at a reasonable royalty to anyone whose work is approved by AEC.

To replace the incentive to invention normally provided by the patent system, the act sets up a system of payment by the commission. Anyone whose patent is wiped out by the act or is requisitioned by AEC is entitled to just compensation from the commission. And in future, anyone who makes a discovery in fields where patents are forbidden is to receive fair payment from AEC.

As a practical matter, the panel report shows, the cancellation of existing patents has not caused the trouble that might have been expected. The vast majority of the 2,300 or so atomic patents applied for or issued have been government owned. Only some twenty seem likely to result in valid claims. The reason for this is that ever since the days when the atom project was handled by the Office of Scientific Research and Development, the policy has been to keep the government in control. Neither OSRD, Manhattan District, nor AEC followed the normal military practice of permitting contractors to take patents on discoveries made in the course of government work.

Basic atomic research contracts included a provision reserving all patent rights to the government. About 60 percent of all contracts awarded were in this form, and they accounted for most of the patentable discoveries.

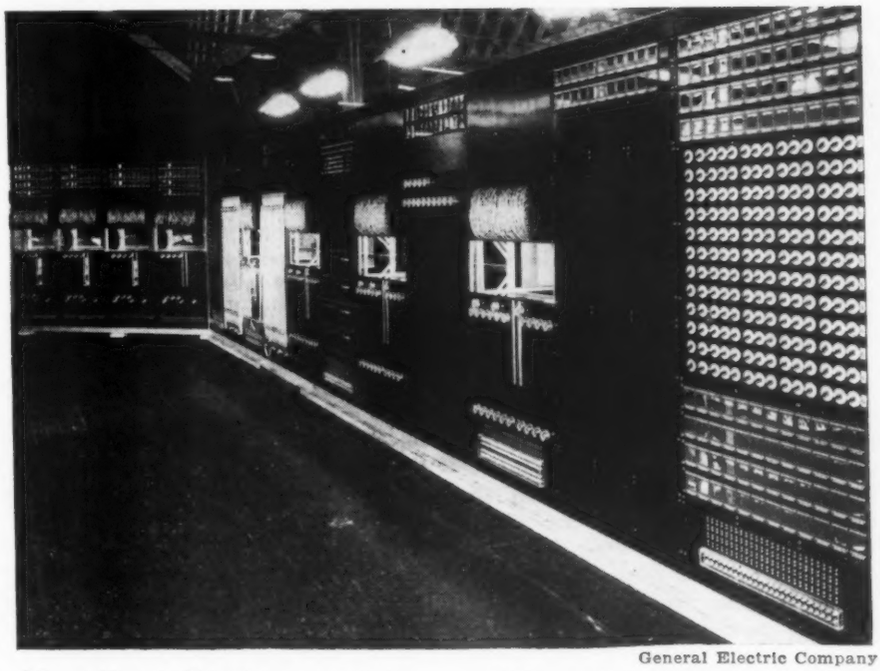
Less basic work, which might involve inventions useful in the contractors' regular business, was covered by contracts keeping the patent for the government but granting the contractor a non-exclusive license for non-atomic application. As an example, this type of deal might be used if a firm specializing in oil diffusion plants were hired to develop a diffusion process for separating uranium isotopes. About 25 percent of the atom project contracts were in this form.

Even where the contract was for routine operation or for design of standard equipment in the contractor's regular line of business, the government kept the patents. But in such cases—some 15 percent of the contracts—an exclusive license for non-atomic use might be given the contractor.

Only a negligible number of atom inventions have yet been made by people not under government contract.

Thus far AEC has not had to deal with any rush of claims—just the few cancelled patents, plus a half-dozen or so valid-looking claims for awards based on new non-patentable discoveries. However, the patent panel recommends that the commission prepare a system of compensation boards.

The panel strongly recommends that the commission make minimum use of its power to compel licensing of patents on atomic applications—to avoid upsetting normal business practices. Instead, AEC should prefer its requisitioning powers or, better yet, should arrange



General Electric Company

MARK II, THE NAVY'S NEW CALCULATING MACHINE, which was unveiled at Harvard University early this year, is now awaiting transfer by the Bureau of Ordnance to the Naval Proving Ground, Dahlgren, Va. The huge "automatic sequence control calculator," which fills a room 50 by 60 ft, was developed by Harvard for the Navy's use in solving ballistics problems. Six important mathematical functions—reciprocal, reciprocal square root, logarithm, exponential, cosine and arc tangent—are built into the machine, which can solve a multiplication problem involving billions in seven-tenths of a second and can add numbers running into billions in 1/5 of a second.

Any breakdown in the wiring sets off a complex alarm and light system in all parts of the machine. Since the machine is made of hundreds of separate parts, faulty parts can be replaced without disturbing the whole calculator.

informal settlement of any disputes over use of patents.

As long as the overwhelming bulk of atom work is done with government money, this will not be difficult, as is exemplified by one of the few cases the commission has had to deal with to date. This involved a laboratory that had patented an instrument for atomic research, which was being made under license by a manufacturing firm. The inventor came to AEC in some distress, because the manufacturer was arguing that the patent was invalid under the Atomic Energy Act. In this case, AEC could have recognized the manufacturer's claim and compensated the inventor. But it turned out that the manufacturer was producing entirely for AEC account. So the commission was able to maintain at least the fiction of normal business relations by advising the manufacturer and the inventor to negotiate a fair royalty—and then accepting the royalty as a "cost" in its contract with the manufacturer.

Army and Navy Evaluating Weapons Development

Design and development of weapons, rather than procurement, will be the major activity of Army and Navy ordnance organizations for some years to come. The two services are already spending considerably more ordnance money on research and on development contracts leading to production of one or two prototypes than on procurement of standard armament for troops or the fleet.

Both services are in a peculiar interim position. Left over from the war are stocks of nearly every sort of armament and munition more than ample for years ahead. In a technical sense these are obsolete; better designs have already been developed for almost everything. But they are as good as anyone else has in quantity.

At the same time, it is recognized that even the improved versions of conventional armament will be obsolete, and in more than a purely technical sense, sometime in the not too distant future. The art of war is on the verge of a tremendous technological revolution more or less equivalent to that precipitated by the introduction of gunpowder. Eventually, the dominant weapons will be families of guided missiles, mounting atomic or chemical warheads, of tremendous range, with speeds measured in miles per second, seeking out their targets by control from base or by built-in detectors.

In this situation, military policy is to push ahead with the underlying research needed for the revolutionary new weapons; to continue development work on improved conventional armament that can be put under contract if sudden mobilization should become necessary; but to rely on existing stocks for equipping the present armed forces.

For example, the Navy has developed automatic-loading designs of greatly increased firepower for the six- and eight-inch guns used for cruiser armament. These are being installed on the new ships now being completed, but no effort is being made to replace the batteries of existing ships.

Army ordnance procurement is now almost negligible, limited to a few training items. A moderate quantity of small arms ammunition is being bought. Rubber treads are being installed on tanks to reduce damage to roads in maneuver areas Army chiefs would like to start a ten-year replacement program on vehicles, but so far they have not been able to get around the existence of a surplus of military trucks and cars. In any case, manufacturers unable to supply their civilian markets have little interest in military business.

The Navy—the "first-line" service—is a little more active in procurement. It has one major program of replacing the 40-mm. anti-aircraft machine gun with the 3-in. automatic-fire gun on all but the smallest craft. New fire-control systems, particularly for the 5-in. batteries are being bought from the same companies (Ford Instrument, Arma, G.E.) that did this work before the war. VT fuzes are being bought to modernize anti-aircraft ammunition, as are some new torpedo components. However, the Navy purchases amount to only 35 million dollars a year.

OTS Deadline Speeds Review of German Data

The Office of Technical Services is rushing its program to get a speedy review and analysis of the 500 reels of microfilmed German-language documents containing German scientific and technical data. While the deadline seems a long way off—June 30 of next year—OTS proceeds on the assumption that its life will end on that date, and the mass of material to be identified and reviewed under difficult circumstances makes speed imperative.

First step has been the publication, in two special issues of the weekly "Bibliography," of the titles of the 5000 reels. This provides for general distribution of available information.

In the organized program to have these German-language documents made available in English, more than 150 offers of assistance have been received by OTS from technical societies, trade associations, universities, private companies, and industrial research laboratories.

OTS has already placed in the hands of reviewers about 500 reels for a first reading. Through use of a printed check-sheet, OTS hopes to have quickly from volunteer reviewers an evaluation of the material sent them. In this way, OTS hopes to sift the wheat from the chaff, and concentrate its efforts during the next months only on German-language reports considered as having immediate and potential value to U. S. industry.

AEC Takes Over Aircraft Propulsion Project

The Atomic Energy Commission is scheduled to take over one of the last atomic programs still in military hands. The program to be transferred is NEPA (Nuclear Energy for Propulsion of Aircraft), a research project carried on by the Air Forces to develop an atomic-powered plane.

Fairchild is the organizer and prime contractor; several other aircraft and engine firms are subcontractors. Now about a year old, NEPA has been a "stepchild," and has had low priority on manpower. Last month the top-level Joint Research and Development Board (the "Joint" has been dropped since Army-Navy unification) reviewed preliminary NEPA results, approved, and gave a definite go-ahead to engineering plans. At the same time, the board recommended that the Fairchild contract be taken over by the Atomic Energy Commission, to be worked into the priorities on manpower and material governing the atomic program.

Air Force generals are not happy, but they are keeping the peace, seeing little hope of changing the directive. They are concentrating on keeping a voice in administration of the contract, and will go to the White House if necessary to get it.

Transfer of NEPA will still further increase AEC's concentration on military applications of atomic fission. Weapon development already accounts for something like 90 percent of AEC activity. Projects for peaceful utilization of nuclear energy are being pushed ever further into the background.

One effect of AEC's present emphasis is that it is losing "friends" in Washington. AEC is still under heavy fire from the Congressional group that wants to put the atom under military control. The armed forces are still "sniping" at AEC. And the Com-

mission's one-time friends—the people who fought for civilian control of the atom and for confirmation of the present commission—are turning against it. They say the civilian AEC is developing the same narrow weapon-mindedness they feared would result from military control.

World Engineering Conference

FURTHERANCE OF PLANS for a permanent World Engineering Conference, in which American engineers are playing a leading role, was the order of business at a meeting of the council and executive board of the Conference in Zurich, Switzerland, September 9 to 12. Stewart E. Reimel, secretary of the committee on international relations of the Engineers Joint Council, with headquarters at 29 West 39th Street, New York, attended this meeting. He represented the United States National Committee for the World Engineering Conference.

Provisional plans for the international technical body were made at a meeting of engineers and scientists held in Paris last September. The U. S. committee is sponsored by three of the leading engineering societies in this country, the American Society of Civil Engineers, The American Society of Mechanical Engineers and the American Institutue of Chemical Engineers. Some 50 or more other U. S. engineering societies will be invited to join.

Eight other nations signed the minutes at the Paris meeting, and others are expected to come in, making the project world wide in scope. The advancement of engineering knowledge and the exchange of technical information among countries for the benefit of all are aims of the Conference.

Mr. Reimel remained in Europe to represent The American Society of Mechanical Engineers at the centenary of the Royal Netherlands Institution of Engineers at The Hague.

Foreign Reports
. . . . . from McGraw-Hill World News

British, Dutch, Belgians Sign Plastics Agreement

An agreement has been signed in Delft, Holland, to stimulate research and pool new inventions in the plastics field in the Netherlands, Belgium and Great Britain. The three parties to the two-year agreement are the British Institute for Plastics Technology, the Flemish Engineers Association and the Delft Research Laboratories for Applied Sciences.

Commenting on the agreement, J. J. Cleaver, one of the directors of The British Institute, said that Great Britain is not behind in theoretical development of plastics but it is lagging behind the United States in commercial exploitation. The present agreement, he said, is aimed at elimination of competition between the three countries and cooperation in order to catch up with this lag. He added that they look forward to future cooperation with the United States.

Russian Claim Wood Laminate As Substitute for Metals

A laminated wood material called "lignophole" is reported to have been developed by the Central Soviet Scientific-Research Wood-Chemical Institute as a substitute for a number of metals. Hailed as a new development, reports indicate that the material is a high-pressure laminate of a type that is conventional in the United States. It is made from pine or birch sheets laid up with synthetic resins, and set with heat and pressure. By varying the species of wood, the arrangement of the finely cut sheets, the pressure and type of resin used, materials of varying properties are obtained. These materials are being used for the production of bearings ordinarily made of non ferrous metals.

The Russian Patent System

With new inventions and technical improvements playing an important part in the increase of production, the Russian state had to find ways to encourage individual inventors as well as the "invention shops" supported by various industrial organizations.

Two methods are legally open to Russian inventors who desire to protect their rights: Obtaining a patent in the same way as in "capitalistic countries;" or getting an "originator's certificate." In practice, however, patents are granted only to foreign workers in Russia. They are granted for 15 years and can be sold either to an industrial enterprise or to a government department, in Russian currency only. The Russian inventor gets an "originator's certificate," which is also generally more remunerative.

Any invention for which an originator's certificate is granted becomes state property. The inventor, however, receives an indemnity the amount of which is calculated on the basis of the savings which the application of the invention in the plant using it represents. As a rule, this indemnity represents from 10 to 25 percent of the savings, as established by the plant management.

The invention is then published in the trade papers. If it is adopted in other plants, the inventor also receives from the latter the same percentage of the savings. The publication can theoretically only be made with the permission of the originator, but the law considers the hiding of an invention by a plant or authority to be a crime. Thus, it is hardly feasible for an inventor to refuse permission to publish.

Various government departments have their own invention service and deal directly with the inventors on matters of protection, delivery of originator's certificates and registration of the latter. But the overall control of the granting of originator's certificates is the responsibility of the trade unions.

Professional "inventors" receive various advantages, as for instance, freedom of taxation on indemnities up to 6,000 roubles; 2 or 3 supplementary weeks of vacation; hospitalization tickets in sanatoria, rest homes and the like; and even larger homes to live in than ordinary workers. Another form of encouragement is that the invention usually bears the originator's name, and the originator's rights can be inherited by his direct descendents.

Russian Portable Optical Pyrometer

A portable optical pyrometer weighing 5½ lb. and allowing temperatures to be gauged from 800 to 2,000 deg. C., has been tested successfully by the Moscow State Institute of Measures and Measuring Instruments. The new pyrometer is to be used in metallurgical, glass and other industries. This replaces bulky apparatus hitherto produced for this purpose.

New Plant Devoted to Laminating Plastics

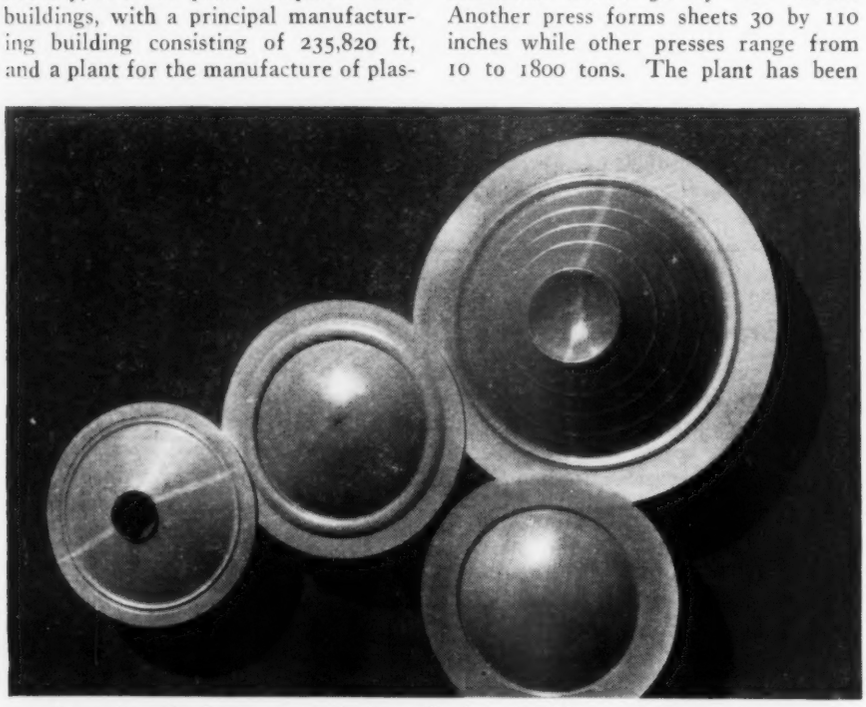
A NEW MANUFACTURING PLANT devoted exclusively to the production of laminated plastics products has been opened by the General Electric Company in Coshocton, Ohio. Said to be the largest factory of its kind in the country, the new plant comprises three buildings, with a principal manufacturing building consisting of 235,820 ft, and a plant for the manufacture of plastics varnishes. Explosion-proof lighting fixtures and power distribution equipment have been installed throughout the isolated varnish plant.

Largest press in the new plant is of 5,000 ton capacity, capable of producing laminated sheets 50 by 100 inches. Another press forms sheets 30 by 110 inches while other presses range from 10 to 1800 tons. The plant has been designed to meet the requirements of laminated plastics manufacture of everything from gears and bearings to insulators and refrigerator door panels.

Air-conditioning and special wall construction have been employed to maintain the close control of temperature and humidity required in the functional storage and build-up departments, prepared material storage, and treated material roll storage. Atmospheric conditions are maintained at 70 F dry bulb and 35 percent relative humidity by means of three special air-conditioning systems, equipment for which is located on suspended mezzanine platforms convenient to the areas served. Cooling required for these areas—totaling 17,200 sq ft—is provided by mechanical refrigeration. Electromatic filters have been installed in these systems which provide 6.7 air changes per hour.

Hundreds of supply and exhaust fans, the largest of which is 100 in. in diameter, 17 ft high, and handles more than 100,000 cu ft of air per minute, extend through the insulated steel roof deck and furnish controlled ventilation to all other sections of the main manufacturing building. Heat produced in certain molding and other operations is trapped in these areas and speedily exhausted to the outside by drawing air from the surrounding areas over the heat-producing equipment at high velocity.

Chemicals for use in various urea and phenolic resin compounds are mixed in the varnish building and piped underground to the manufacturing building through a tunnel lined on both sides by process piping.



Loud speaker diaphragms, used when shock and moisture resistance is essential, are molded from a linen-base fabric and thermosetting resin at Coshocton.

In hydraulic presses, plies of resin-impregnated paper and cloth are molded into refrigerator strips at new laminating plant of General Electric plastics division.

Temper Brittleness in Steel

ACCEPTED EXPLANATIONS of the nature and causes of temper brittleness in steel may be incorrect according to a research report by the Office of Technical Services, Department of Commerce. No conclusions are yet justified as to the effect of steel making practices on the extent of the transformation.

The report, prepared by Capt. John H. Hollomon, Ordnance Dept., U. S. Army, for the Watertown (Mass.) Arsenal, surveys the available information on temper brittleness in steels:

1. The effect of the temper brittleness transformation on tensile, impact and other physical properties.

2. The effect of variables, including time and temperature of transformation; structure; composition, with particular reference to plain carbon steels and other components; and forming, casting and refining practices.

3. The effect of precipitation in the mechanism of temper brittleness.

Electronic Micrometer Based on Shielding Principle

THE PRINCIPLE that the field surrounding a coil fed with alternating current will induce current in an adjacent coil and that the amount of current thus induced can be controlled by placing a shield or a low-resistance conductive medium at various distances from the latter coil is employed to make a linear reading device for use as an electronic micrometer. The shield is placed not between the primary and secondary coils, but adjacent to the latter. Its distance from the secondary coil determines the amount of energy produced in this coil.

The new device, developed by M. L. Greenough of the National Bureau of Standards, was primarily designed to afford a means for measuring thickness of the oil film in the bearings of a large Navy turbine shaft. The device has a number of important applications: as a micrometer, a phonograph pick-up, a microphone, and for similar purposes.

The electronic micrometer designed at the Bureau utilizes the fact that radio frequency energy radiated from a coil is at zero at the surface of a perfectly conducting shield adjacent to that coil. This phenomenon occurs because eddy currents are set up in the shield by the field of the radiating coil, and these eddy currents set up an opposing magnetic field at the surface of the shield.

The radiating coil is fed at high frequency current. When the micrometer is held at some distance from any metallic object, the field from the radiating coil induces voltage in the secondary (or pick-up) coil, and this induced voltage is measured either on an oscilloscope or by an alternating current meter. The linear indication of the change in distance between the micrometer and the metal background is indicated on the meter or oscilloscope.

When used as a micrometer, the coil assembly is mounted on a movable shaft in such manner that it can be caused to approach or recede from a metallic plate. The material to be measured is placed between the pick-up coil and the metallic plate and is presed lightly between them. When the material is removed, the amount of current generated in the pick-up coil is an indication of the thickness of the material which occupied the space. The meter indicating the output of the coil is calibrated, not in current or voltage, but in thousands of an inch in order to give a direct measure of distance or thickness.

When the electronic micrometer was used to measure the displacement of a turbine shaft in its journal, four of the devices were spaced equally around the turbine shaft. This arrangement is so sensitive that a deflection of 1/100 in. of the center of a six inch shaft provides a two-inch deflection of the center spot of a cathode ray tube. The micrometer is about ½ in. in diameter by ¼ in. in length and is able to measure distances from zero to 0.02 inch. Readings to 0.0001 in. are easily obtained. The indication on a meter is linear to within a fraction of one percent.

When the principle is employed in a phonograph pick-up, the vibration of a flat-plate armature fastened to the needle causes a change in the position of this armature with respect to the pick-up coil. This causes alternation in the output of the pick-up coil, and these electrical fluctuations may be rectified and fed into an amplifier for reproduction. By selection of suitable frequencies, the output of the pick-up coil may be high frequency fed directly into the intermediate frequency stages of a superheterodyne phonograph-radio receiver in any of a variety of ways.

When the electronic micrometer is used as a microphone, vibrations adjacent to the pick-up coil are created by a metallic diaphragm, and the movement of this diaphragm causes fluctuations in the output of the pick-up coil. The action is similar to that of the device used as a phonograph pick-up. With a slight modification, the device can be used as a thermometer.

Another application of the device is the tachometer or speed indicator. In this case, the end plate of a flyball governor may be so mounted as to approach or recede from the pick-up coil as the speed of rotation of the governor increases or decreases. It can be applied to many similar uses.

Measurement of the thickness of a paint spot with the new electronic thickness gauge developed by the National Bureau of Standards is demonstrated by M. L. Greenough, Bureau scientist who designed the new micrometer.

New Machine Tools Developed by Germans

COMBINATION BORING AND MILLING MACHINES and swivel head vertical milling machines were two of the very few new machine tools developed by the Germans during the war, according to a report on German machine tool practice by the Office of Technical Services, Department of Commerce.

The report was made by OTS investigators L. E. Mehlhope and L. H. Martin, field engineers of the Cincinnati Milling & Grinding Machine Co. of Cincinnati, Ohio and Landis Tool Co. of Waynesboro, Pa., respectively. They visited 26 German machine tool manufacturers of lathes, grinders and milling machines.

The combination boring and milling machines were made to increase precision and save resetting of the work. Work was moved from one set of cutters to another. The cycle was not simultaneous but successive. The investigators found swivel live spindle headstocks and swivel wheel heads on grinding machines to be more versatile

than U. S. models although not as rigid or productive.

In the grinding field, the investigators noted a tendency to build machines with low power for a designated work swing. Ten-inch grinders, for example, would have range for full 10 inches, but power, weight and grinding wheel capacity would be more nearly comparable to our 6-inch grinders.

Profile milling seemed to have been neglected in Germany until the war started, the report states. Most of the milling machines were made by Rhorschach in Switzerland.

The investigators found no independent development of automatic die sinking. Broaching was little used and not at all on cast iron. Where broaching was used, the applications were good and compared favorably with U. S. practice, the report states.

At the Gerb Heller Machinenfabrik at Nurtingen the investigators found a giant machine for turn milling the crank pins and adjacent web faces of Diesel motor crankshafts. Since the crankshafts were large, it was necessary to use a 40-inch diameter cutter. Plant personnel claimed that the machine, estimated to weigh from 150,000 to 200,000 pounds, could finish a crankshaft in 24 minutes compared with 160 minutes by previous turning methods.

In the turn milling operation the crankshaft is mounted between centers and supported additionally by journal rests on two finished main bearings. Six cutters mounted on spindle carriers are spaced at intervals of 120 degrees about the axis of the crankshaft. Two of the cutters are located vertically under the crankshaft and two on each side of the shaft 30 degrees above the horizontal. Each spindle carrier is slide mounted on a saddle so that it can move the cutter to and from the work axis to feed the cutter to the work. The saddles are adjustably mounted on the bed in order to space the cutters axially for different lengths of crankshafts. As the crankshaft rotates any pin describes a circle in space and in order to maintain contact between work and cutter, the spindle carriers move to and from the work axis. Movement is controlled by hydraulic tracing. A master cam mounted on the work headstock spindle engages tracer heads operating from each spindle carrier.

The investigators found that the Germans did not make any appreciable progress on high speed negative rake milling, which was developed during the war in the United States.

Orders for the report, (PB-63855; "Machine tool practice in Germany," photostat, $6; microfilm, $2) should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D. C., and should be accompanied by check or money order, payable to the Treasurer of the U. S.

DISCUSSIONS AND COMMENTS FROM READERS

Standard Drafting Practice

To the Editor:

In looking through PRODUCT ENGINEERING, July 1947, we have found what we believe to be a misprint and an error on a drawing in the article "Basic Standard Drafting Practice Guarantees Correct Interpretation", by G. E. Rowbotham, Project Engineer, Fisher Body-Ternstedt Div., General Motors Corp.

On drawing "C", page 138 of this issue, we believe dimension 3.28 should be given as an inside dimension. If the dimension is not critical, this form would be easier for the die maker, and dimension 3.23 could be eliminated. We also feel that a vertical centerline should be added to, and indicated on, the drawing because the holes are centered with the 3.41 ± 0.01 dimension. The centerline is also necessary because all dimensions taken from the centers of these holes can shift to the right or left of the ends within the limits of the 4.34 dimension. The angle so indicated on drawing "D" should, of course, be put on drawing "C". This is done to insure ease of inspection.

—SANFORD GEUSS AND JACK HODGES
Webster Groves, Mo.

To the Editor:

I should like to thank Mr. Sanford Geuss and Mr. Jack Hodges for their constructive criticism of the article, "Basic Standard Drafting Practice."

It is true that the most suitable method of dimensioning the part in question, from a tooling standpoint, would be to dimension the part from the inside surfaces as proposed by their letter. However, from a functional standpoint, the method shown is better. The subject part is a support that is riveted to both lower channels, one on each side, of the seat adjuster and due to the design of the unit, it is absolutely necessary to hold the angles of the left hand and right hand channels as close as possible to each other. As far as the vertical centerline is concerned, I believe it is quite apparent that the centerline of the mounting hole, from which the 0.34 R is located, is at right angles to the base line. It will be granted that in some cases it would be advisable to give an angular dimension and eliminate the 3.23 dimension in order to facilitate inspection. However, on high production parts where special gages are used, it is not always practicable to employ angular dimensioning. Special gages are used to inspect the supports and that is the reason for the present method of dimensioning.

From the foregoing, it is apparent that the subject part is dimensioned with the understanding, mentioned in my article, that dimensions used by manufacturing may or may not be the same as those specified on the drawing, but are satisfactory so long as the finished part measures up to the specifications and requirements presented on the drawing; assuming, of course, that a clear understanding of the requirements of the part exists from a functional standpoint. —G. E. ROWBOTHAM

Wall Thickness of Pipes With Closed Ends

To the Editor:

I read with interest the article "Optimum Hydraulic Pressure for Minimum Cylinder Diameter", by P. J. Lindner, PRODUCT ENGINEERING, June 1947. However, I feel that some important wall thickness corrections were omitted from the discussion. Formulas generally used in determining cylinder wall thicknesses refer to pipes with open ends. Pipes are often strongly fixed at the ends and the formulas must be corrected accordingly.

There are two formulas used in calculating wall thicknesses for cylinders:

Where

r = inside radius, in.
p = fluid pressure, psi
t = wall thickness, in.
S = tangential hoop stress, psi

$$t = \frac{p\,r}{S} \qquad (1)$$

$$t = r\left(\sqrt{\frac{S+p}{S-p}} - 1\right) \qquad (2)$$

Equation (1) is used for thin-walled pipes and Eq. (2), Lamé's Formula, is used for thick-walled pipes. The present problem concerns discovery of factors necessary to convert these formulas into useable form for cylinders with fixed ends.

Tests performed to find the actual bursting strengths of two seamless steel pipes have shown the incorrectness of

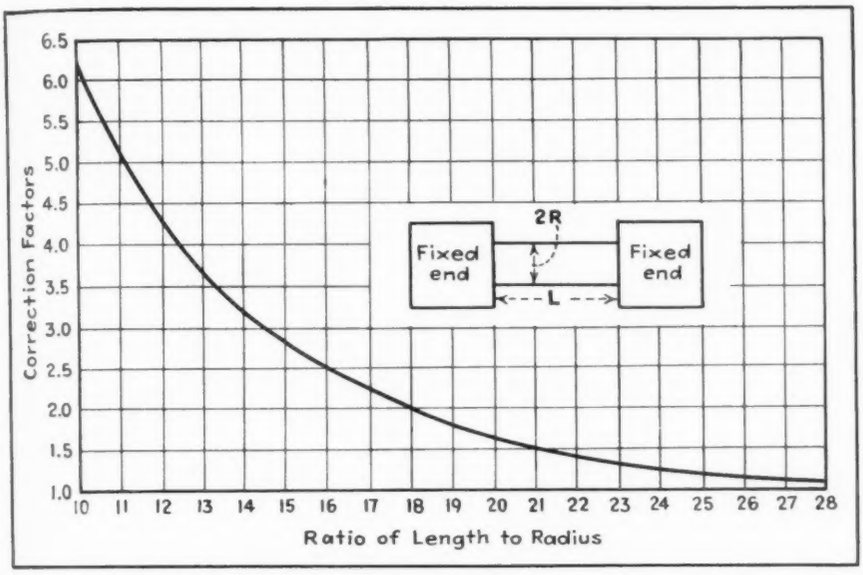


Fig. 1—Curve of correction factors vs. length-radius ratio for pipes with fixed ends.

the formulas. The pipes were manufactured from materials with an ultimate tensile stress of 61,200 psi and 21.3 percent elongation. The first pipe had an inside radius of 2.39 in., a wall thickness of 0.235 in. and a length between end fixtures, L, of 39.38 inches. As calculated by Eq. (1), the bursting pressure should have been:

$$p = \frac{61{,}200 \times 0.235}{2.39} = 6{,}175 \text{ psi}$$

However, the actual pressure was 16,350 psi, a value 2.65 times higher than calculated.

An even more striking result was shown by the second pipe with a wall thickness of 0.276 in., an outside radius, R, of 3.125 in. and a length of 39.38 inches. This pipe burst at a pressure of 28,000 psi, 5.35 times the 5,230 psi pressure calculated.

For the second pipe, the ratio of the length between fixtures to the outside radius of the pipe was:

$$\frac{L}{R} = \frac{39.38}{3.125} = 12.6$$

The discrepancies between actual and calculated bursting pressures are dependent on the ratio

$$\left(\frac{L}{R}\right)^2$$

The graph of Fig. 1 shows the effect of the length-radius ratio on the strength of pipe. Values of the calculated correction factors appear on the left hand vertical scale. Thus, for a 5¼ in. OD pipe with a length-radius ratio of 20, bursting pressure will be 1.635 times that calculated by Eq. (1).

The graph of Fig. 1 does not apply to cylinders closed by flat ends, such as those for a forging press, because the effect of flat ends on the strength of structures is different. The following empirical formula can be used:

$$p = S\left[\frac{2rt + t^2}{2r^2 + 2rt + t^2} + \frac{3t}{L}\right] \qquad (3)$$

The value of the first term in the bracket of Eq. (3) is a modified Lamé formula. The second term represents the additional stress corrections introduced by flat bottoms 1.5 times as thick as the cylinder wall. The results of the application of #(3) are given in the following table:

Where

p = working pressure, psi
L = Length of cylinder, in.
r = inside radius, in.
t_o = Lamé wall thickness, in.
t = corrected wall thickness, in.
η = Corrective factor for wall thickness

p	L	r	t_o	t	η
2,844	30	9.5	2.58	1.2	0.465
4,266	30	8.0	3.60	2.0	0.556
5,688	30	7.0	4.73	2.55	0.538

It can be seen that wall thicknesses are 1.8 to 2 times less than calculated by the Lamé formula.

In practice, the thickness of the wall will depend on the construction of the cylinder, particularly on its method of attachment to the frame. The wall thickness correction will also depend on methods used in the production of the hydraulic cylinder.

—Victor Tatarinov
Pilsen, Czechoslovakia

MEETINGS

November 2–5
National Tool and Die Manufacturers Association — Annual meeting, Benjamin Franklin Hotel, Philadelphia, Pa.

November 3–5
National Electronics Conference — Sponsored by the **American Institute of Electrical Engineers,** and the **Institute of Radio Engineers;** Edgewater Beach Hotel, Chicago, Ill.

November 5–7
Industrial Management Society — 11th National Time and Motion Study Clinic, Sheraton Hotel, Chicago, Ill.

November 5–7
American Society of Body Engineers —Annual convention, Rackham Memorial Bldg., Detroit, Mich.

November 6–7
Society of Automotive Engineers—Fuels and Lubricants meeting, Mayo Hotel, Tulsa, Okla.

December 1–3
Society of Automotive Engineers—Air Transport Meeting, Hotel Continental, Kansas City, Mo.

December 1–5
American Society of Mechanical Engineers—68th Annual meeting, Atlantic City, N. J.

December 1–6
Twenty-First Chemical Industries Exposition — Grand Central Palace, New York, N. Y.

December 3-5
National Association of Manufacturers—Annual Congress, Waldorf-Astoria, New York.

December 4–6
Society for Experimental Stress Analysis—Annual Meeting, Hotel Pennsylvania, New York, N. Y.

December 26-31
American Association for Advancement of Science—National Meeting, Chicago, Ill.

December 29–30
American Chemical Society—Fourteenth Annual Symposium, Chicago, Ill.

January 12–16
Society of Automotive Engineers — Annual Meeting, Hotel Book Cadillac, Detroit, Mich.

January 12-16
National Materials Handling Exposition—Public Auditorium, Cleveland, Ohio.

January 26–29
Refrigeration Equipment Manufacturers Association—Refrigeration and Air Conditioning Exposition, Cleveland, Ohio.

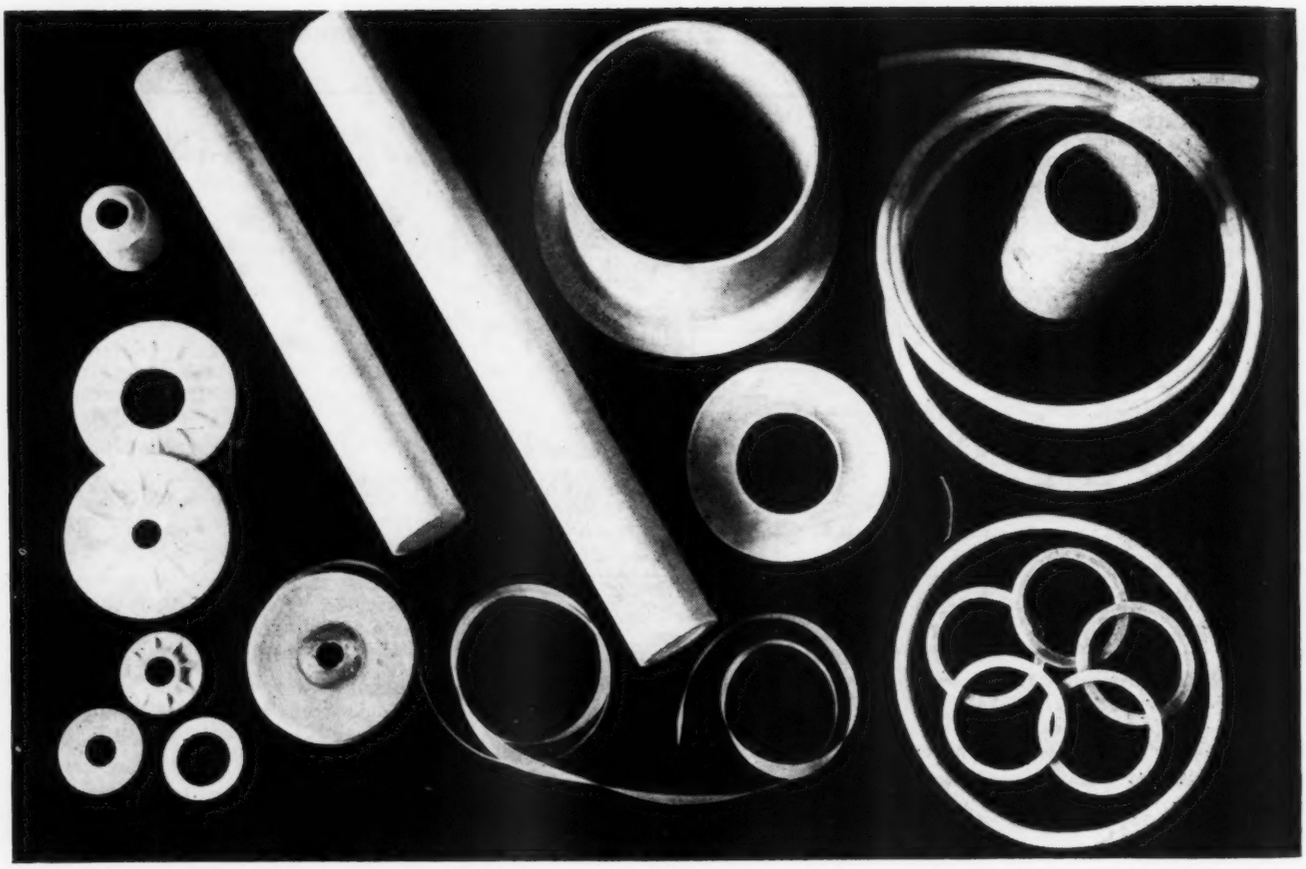


Fig. 1—Flared tubing, rod, pipe, gaskets, beading, coaxial cable spacers, valve-stem packing and tape are all made of Teflon.

HIGH HEAT AND CORROSION

EVERETT B. YELTON
Plastics Department, E. I. du Pont de Nemours & Company

Properties and applications of the new thermoplastic material, polytetrafluoroethylene, tradenamed Teflon, which has high heat resistance and is inert to many solvents and chemicals. Its applications include solvent-resistant gaskets and seals, flexible hydraulic diaphragms and high frequency insulating parts.

TEFLON is the tradename of the du Pont Company for the polymer of tetrafluoroethylene. It is a solid, granular material, which can be molded and extruded. The polymer consists of long straight-chain molecules packed closely together. The combination of this structure with the strength of the chemical bond between carbon and fluorine is responsible for its extreme chemical inertness and solvent-resistance, high impact strength over a wide temperature range, low dielectric losses, and resistance to elevated temperatures.

These properties make this material well suited for gaskets and packings in chemical equipment, and for electrical insulation for high-frequency and high-temperature service. In such uses the long life of the plastic, and the consequent saving in maintenance labor, more than compensate for its cost. Table I shows a list of properties.

Teflon is classed as a thermoplastic, but its extremely high softening point and the high viscosity of the softened material have prevented its being molded by standard procedures. By using special techniques, however, it is possible to mold simple articles.

Normally, Teflon has a crystalline structure, but when heated above 327 C it is changed to an amorphous jelly. The sharpness of the transition point is shown in Fig. 2, on which coefficient of expansion has been plotted against temperature. The marked increase in coefficient of expansion occurs at the transition point. In molding operations, temperatures greater than 327 C are required to insure welding of the particles of the polymer, but at temperatures greater than 400 C Teflon will decompose to yield the monomer plus fluorine-containing gases. Some of these gases are toxic, and good ventilation must be provided for workmen handling Teflon at elevated temperatures. For complete safety, care should be taken

Table I—Typical Properties of Polytetrafluoroethylene

Data given represent standard commercial grades of material

Property	Value	Method of Test
Specific gravity	2.1–2.3	D793–44T
Tensile strength at 77 F., psi	2000–4500	D412–41T[1]
Elongation at 77 F, %	300–400	Die C
Flexural strength at 77 F, psi	2000	D650–42T[2]
Stiffness at 77 F, psi (0.125 in.)	60,000	D747–43T
Impact strength, Izod, −70, 77, 170 F, ft.-lb. per in.	2.0, 4.0, 6.0	D256–41T
Hardness, "D", Durometer	55	.....
Compressive strength, psi at 0.1 percent deformation	1700	D695–42T
Yield temperature, deg. F.	>320	Arl. M–8
Heat-distortion temperature, low-load, deg. F	266	D648–(B)–44T
Specific heat, cal/g/deg. C.	0.25	.....[3]
Coefficient of expansion per deg. F. (77–140 F.)	5.5×10^{-5}	D696–42T
Thermal conductivity, Btu./hr./ft.²/°F./in. (0.18 in.)	1.7	Arl. P–32[4]
Brittleness temperature, deg. F.	<−100	D746–43T
Dielectric strength, short-time, volt per mil (0.080 in.)	480	D149–40T[5]
Volume resistivity, ohm-cm	10^{16}	D257–38
Dielectric constant at 60, 10^3, 10^6, 10^8 cycles	2.0	D150–40T
Power factor at 60, 10^3, 10^6, 10^8 cycles	<0.0005	D150–40T
Water-absorption, percent	0.00	D570–42[6]
Moisture permeability, g/sq. m./24 hr.	0.00–0.5	D697–42T
Outdoor weathering	No detectable change in 1 year	

1—Tensile strength in oriented film may be as high as 15,000 psi.
2—Specimens do not break.
3—Method of mixtures.
4—Cenco-Fitch apparatus.
5—1000–2000 volts per mil in thicknesses 5 to 12 mils.
6—Not wet by water.

RESISTANT PLASTIC

whenever the temperature of Teflon is raised above 200 C, even though the material suffers no detectable loss in weight from being baked at the transition temperature for many hours.

Molded articles of Teflon are opaque, with a waxy surface and a color that varies from white to gray. The gray color results from traces of contaminants, and it can be removed by baking the piece in air or by treating it with strong oxidizing agents. Such treatment causes no measurable change in physical or chemical properties. However, the grayness is rarely objectionable; hence the whitening treatments are seldom applied. Pigments that are stable at 330 to 400 C can be incorporated into Teflon, but as yet there has been no demand for the resin in colored form. A number of inorganic fillers have been added successfully to produce desired changes in properties of the molded pieces.

The chemical resistance of Teflon is outstanding. It withstands the attack of practically all chemicals except molten alkali metals. It has been boiled in several hundred solvents, including a variety of halogenated hydrocarbons, ketones, esters and alcohols, without swelling or any other sign of attack. Teflon can be boiled in aqua regia, hydrofluoric acid, sulphuric acid or nitric acid with no change in weight or properties. It is equally resistant to the attack of strong alkalis. Chlorine, bromine or iodine do not react with Teflon, but fluorine will react under special conditions.

The absorption of water by molded articles of "Teflon" is so low as to be rated as zero by the standard ASTM test. The moisture-transmission of continuous films also is very low.

No cement has yet been found for Teflon. This is unusual and it should make Teflon useful where a non-sticky surface is essential. Thin films of Teflon have found application on heat-sealing machines, to prevent cellophane, wax paper and films of plastic from sticking to the sealing plates. Teflon sheeting has also been used to line conveyors, take-off rolls and driers handling sticky materials. Usually, a few rivets can be used to hold Teflon sheeting in place without reducing the effectiveness of its surface. Other applications have been suggested in the baking and confectionery industries.

Properties

The impact strength of Teflon is relatively high over a wide range of temperatures. At −70 F the Izod impact value is 2.0, and at 170 F the value is 6.0. This in itself is not unique, but the combination of high impact strength, resistance to high temperatures, low dielectric loss, low moisture-absorption and resistance to chemical makes Teflon suited for many special applications.

With the exception of impact strength, the mechanical properties of Teflon are not outstanding, but they are adequate for most uses. When tested in the tensile machine, the material begins to draw when loads of 1,500 to 2,000 psi are reached. When the ultimate of 2,500 to 4,500 psi is attained, the specimen will have elongated 300 to 400 percent.

Like conventional thermoplastics, Teflon is subject to cold flow, but this tendency is not as great as indicated by the value obtained in the standard ASTM heat-distortion test. Thick sections of the polymer are deformed easily under load, but thin sections are less subject to flow.

An important property of thermo-

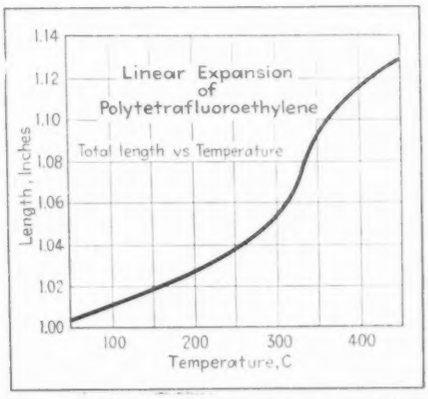
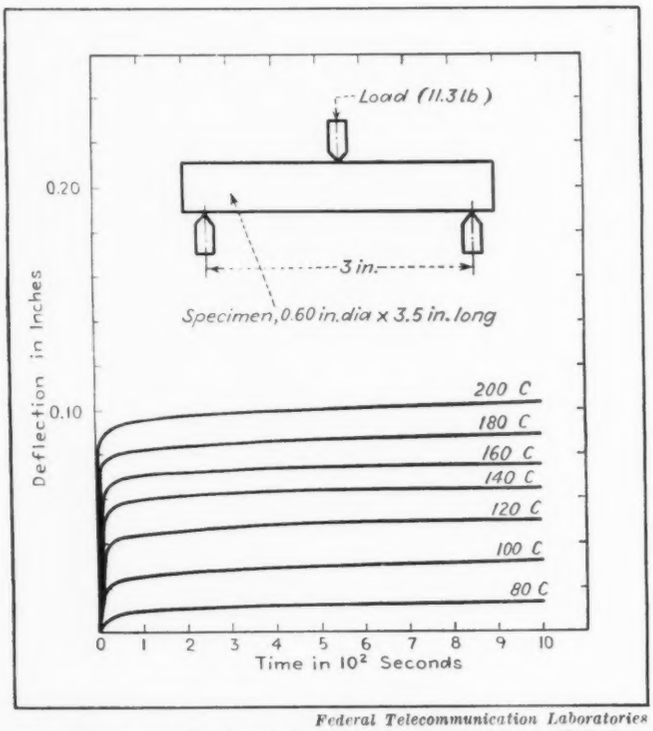
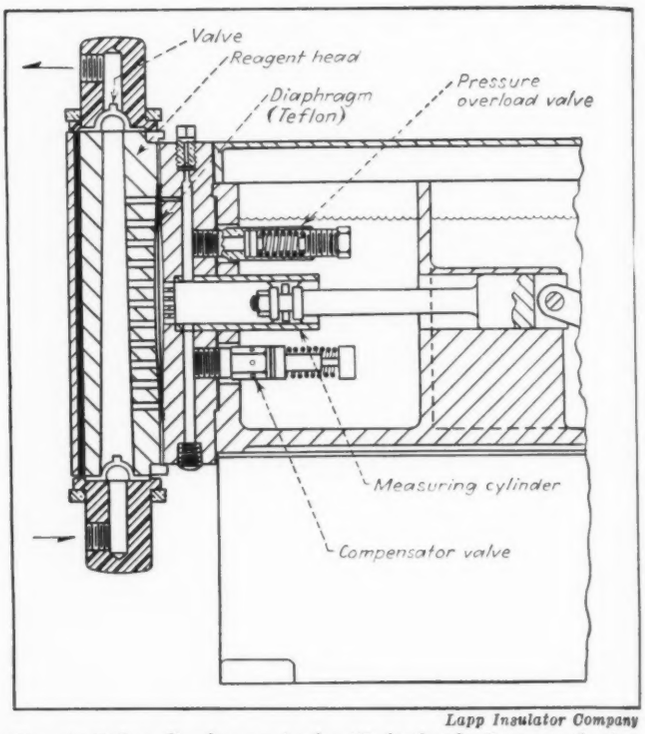


Fig. 2—Sharpness of the transition point, around 327 C, shows the crystalline structure of Teflon.



Federal Telecommunication Laboratories

Fig. 3—A specially-developed heat distortion test of Teflon shows an initial deflection at all temperatures, but after a short time relatively little further deflection occurs.



Lapp Insulator Company

Fig. 4—Teflon diaphragm in the "Pulsafeeder" proportioning pump isolates chemical solution being pumped from operating parts and from hydraulic fluid, up to 5000 psi.

plastic materials for use under load and at varying temperatures is deformation under load. ASTM D647-44T describes a method for measuring this property, and published data for Teflon give temperatures of 62 C and 130 C for the high- and low-load conditions respectively. It has long been recognized, however, that this test is not easily translated into predictions for the safe operation temperature of certain materials. A somewhat different approach is preferred: A rod of the material is simply supported at its ends in a horizontal plane and load is applied at the mid-point. Holding the temperature constant, the deflection against time is then measured. This is repeated for various temperatures.

Results obtained by this method are shown in Fig. 3. There is an initial deflection at all temperatures, but after a certain period of time relatively little further deflection occurs. Also at temperatures as low as 100 C there is an appreciable deflection. Additional study of the deformation and flow properties of this material is definitely indicated.

Table II—Effects of Aging At 200 C On Dissipation Factor of Polytetrafluoroethylene at 3000 Megacycles

Time of Heating Hours	Dissipation Factor	
	Sample 1	Sample 2
0	0.00029	0.00031
168	0.00032	0.00031
504	0.00037	0.00031
672	0.00030	0.00031
1000	0.00034	0.00029

Teflon can be oriented by cold-drawing or rolling. Oriented material exhibits "elastic memory", and when heated above about 300 C it will contract to its original state.

The excellent electrical properties of Teflon, coupled with its heat-stability, give it many potential applications in the power field. One of the limiting features in design of electrical equipment has been the lack of a suitable insulating material that will withstand high temperatures. Thin tapes of Teflon have many possible applications as replacements for more conventional types of insulation. Teflon has excellent resistance to surface arc-over, and, on failing, it melts and vaporizes, rather than carbonizing to leave a conducting path. The electrical losses in Teflon are substantially constant over a frequency range of 60 cps to 10,000 mcps, and lower than those of polystyrene and polyethylene. It is an outstanding dielectric material for color television and radar systems because of its excellent heat-resistance and aging properties.

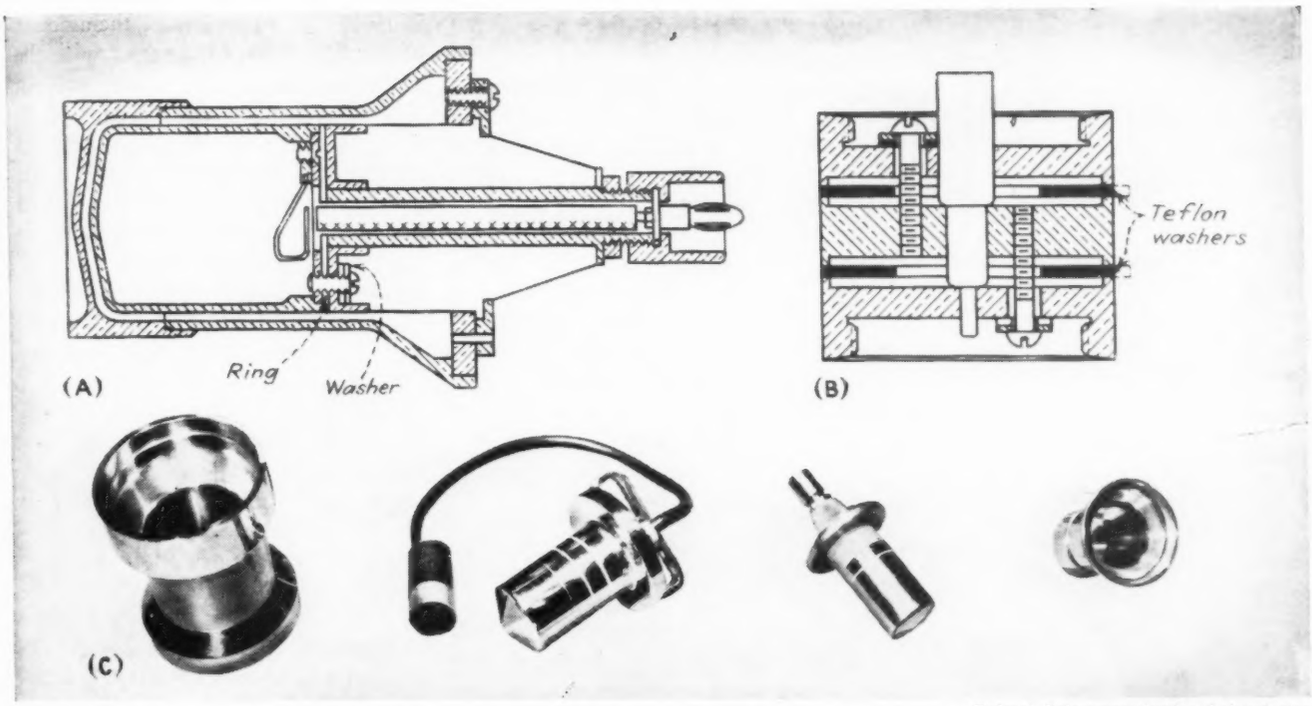
Heating polytetrafluorethylene at 200 C for periods up to 1,000 hours is without effect on the power factor, as shown by Table II. When polyethylene is immersed in a plasticizer such as 2-diethyl hexylphthalate, even at room temperature, the power factor rapidly rises; with Teflon no such change occurs.

With materials such as the silicone fluids and insulating greases, heating with Teflon at 200 C for periods up to 500 hours causes no change in power factor and dielectric constant. In fact, there are no visible signs of physical change. Many other fluids have been tested for their effects on the material, and none has been found that causes a change in properties by prolonged immersion.

Molding and Machining

Because of the high viscosity of Teflon "jelly" it is not possible to produce satisfactory articles by injection molding. The jelly can be forced into the die cavities, but pronounced flow lines are always present in the finished article.

Special molding techniques have



Federal Telecommunication Laboratories

Fig. 5—Dielectric and 60 cycle test cells make use of Teflon. (A) Washers and rings in 60 cycle test cell assembly resist breakdown by electrical current and are inert to liquid dielectrics. (B) Subassembly of the guarded electrode in dielectric test cell has Teflon washers. (C) Partially disassembled dielectric test cells. Ring insulators are made of Teflon.

been developed to yield flat sheets, rods and tubes. Thin films are made by shaving a rod or tube in the same way that wood veneer is shaved from a log. These can be oriented to yield a film with superior electrical properties.

Rods and tubes of Teflon can also be extruded if special techniques are used. At present, it is not feasible to extrude solid rod with a diameter greater than 1½ in. because of difficulties in cooling it. Tubes as large as 4 x 6 in. have been extruded. In general, the greater the inside diameter of the tube the thicker the wall must be, for successful extrusion.

Teflon can be machined easily with standard woodworking or metalworking tools, when they are kept sharp. The material machines better when it is cold, and some rod stocks have been chilled by ice or solid carbon dioxide to facilitate finishing operations. Rods have been ground on a centerless grinder with an accuracy of ± 0.0005 in. In all machining and grinding operations, there must be adequate ventilation to protect the operator from the toxic effect of dust and fumes arising from localized heating by the tool.

Sheets of Teflon can be punched and shaped by the application of pressure. In shaping operations it is possible to draw the sheet until its thickness is reduced by half.

Applications

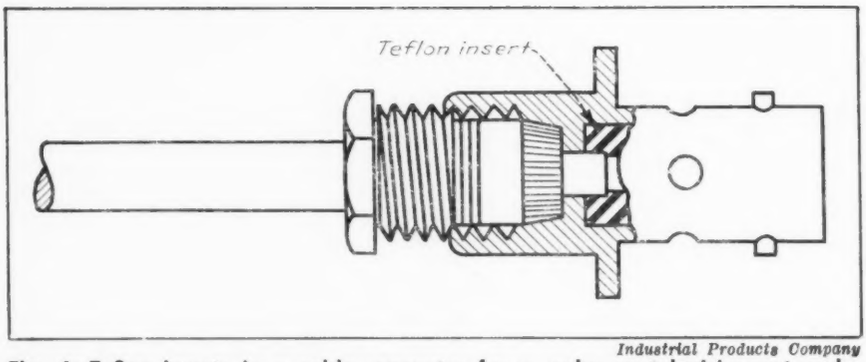
Teflon is finding application where its superior performance and long service life justify its cost. One of its first uses was in gasketing for pipe lines carrying nitrating acid. These gaskets lasted at least one year, and always failed mechanically rather than chemically. The gaskets were frequently torn in dismantling the lines, or were compressed beyond their recovery limit by excessive bolting pressure.

For use on glass equipment, where Teflon of regular grades is not compressible enough to give a tight seal under relatively low bolting pressures, Teflon is made in a porous form. But more satisfactory for glass equipment has been a French-type gasket, in which a thin envelope of Teflon serves to protect a resilient core of rubber or asbestos.

Because of its resistance to chemicals, Teflon has been used as a packing material for valves, autoclaves and centrifugal pumps. An extremely interesting application in this field is the use of Teflon as a diaphragm in the "Pulsafeeder", a proportioning pump for chemicals. As shown in Fig. 4, the Teflon diaphragm or pulsating disk isolates the chemical solution being pumped, from operating parts and from the hydraulic fluid which supplies pressure, up to 5,000 psi. Thus, the diaphragm must not only remain dimensionally stable to deliver measured amounts of liquid, but must be resistant to the action of corrosive chemicals and hydraulic fluid.

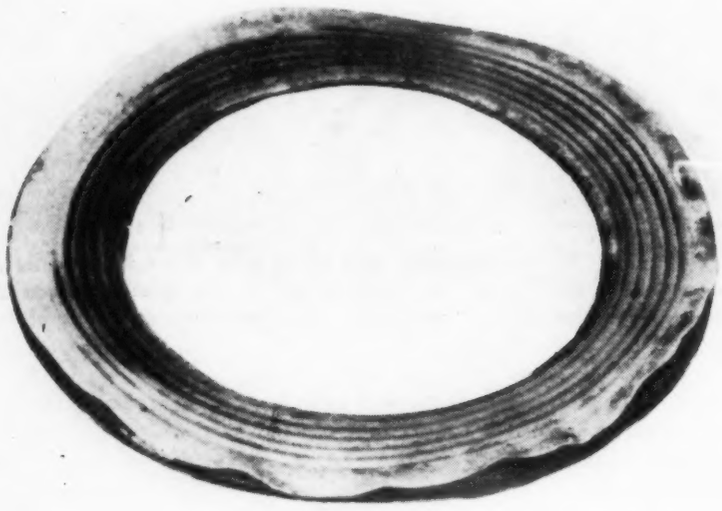
Rings cut from extruded tubing were found unsatisfactory for packing high-speed shafts, because the poor thermal conductivity prevents dissipation of frictional heat by the packing, causing it to expand and seize the shaft. Teflon in various modified forms has been tried for this use, and packings of short fibers, recently developed, are promising. These fibers are bonded together by 9 percent or less of binder, and can then be extruded into a coiled packing or molded into rings by pressure. Packing thus prepared is sufficiently compressible to absorb the expansion produced by frictional heat, without binding on the shaft.

Teflon tapes have been suggested for use as insulation in the electric power field. Their heat-resistance allows the machinery to be operated at



Industrial Products Company

Fig. 6—Teflon inserts in a cable connector for a radar or television set make possible attachment of flexible cables carrying high frequency current.



United States Gasket Company

Fig. 7—After 1 year of service, during which Teflon gasket was subjected to corrosive chemicals, rings on gasket are unbroken, allowing unimpaired action.

higher temperatures and with higher efficiencies than are practicable with present insulating materials. These tapes are being tested as insulation for many different types of electrical equipment.

Teflon's chemical resistance and high dielectric strength are both utilized in an interesting application at the Federal Telecommunication Laboratories, Newark, N. J. In order to test liquid dielectrics, used in transformers, switches, and other electrical equipment, special test cells were devised. As shown in Figs. 5 and 6, Teflon was used as an integral part of the body of one of the cells and for washers and rings in the other. In the 60-cycle test cell, the Teflon ring is used to set off accurately the amount of metallic surface in contact with the dielectric fluid. The space between the inner plunger and the cup is precisely the same all the way around, so that a uniform film of fluid exists over the entire surface. Teflon is used because it is dimensionally stable at all operating temperatures and because it resists the action of the dielectric fluids. Hence, it matches the accuracy which has been machined into the rest of the cell.

Various parts for radio and radar equipment have been made, by machining rods or tubes, and by a specialized molding technique. Teflon is ideally suited to high-frequency applications, because of its low dielectric loss. As shown in Fig. 7, Teflon inserts in a cable connector for a radar or television set make possible attachment of a flexible cable carrying high-frequency current to a rigid assembly.

Other special articles can be molded if the cross-section is not too complicated. Sometimes the article is molded to approximately the desired shape and then finished to dimensions by machining.

Increased experience with the resin has led to the development of simplified methods of working it, and further progress is expected. It is also expected that volume production will reduce the cost of Teflon, but it will remain primarily a working plastic for industry, lacking decorative effect but serviceable under specialized and difficult conditions.

EDITOR'S NOTE: Heat-distortion curves, and data concerning the power factor of Teflon and the dielectric test cells, were contributed by Mr. A. J. Warner of the Federal Telecommunication Laboratories.

German "Chromising" Process

THE GERMAN "CHROMISING" process for diffusing chromium from a volatile chromium compound into steel to improve the surface properties of metal products are described in a report issued by the Office of Technical Services, Department of Commerce. The report was prepared by investigators for the British Intelligence Objectives Sub-Committee.

All of the firms using the process made the same type of products, according to the report. These were: Valves for controlling the flow of various fluids, preheater tubes for preheating air for combustion in the engines of destroyers, bolts which were chromised before threading, and hose connectors for milk delivery hoses and milk cans. The valves were especially resistant to corrosion. Chromising of the hose connectors could be performed over welded joints.

Orders for the report, PB-52873 (mimeographed, 75 cents), should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D. C., accompanied by check or money order, payable to the Treasurer of the United States.

International Nickel Co. Inc.

Fig. 8—Izod impact testing machine with specimen in place and pendulum cocked for swing.

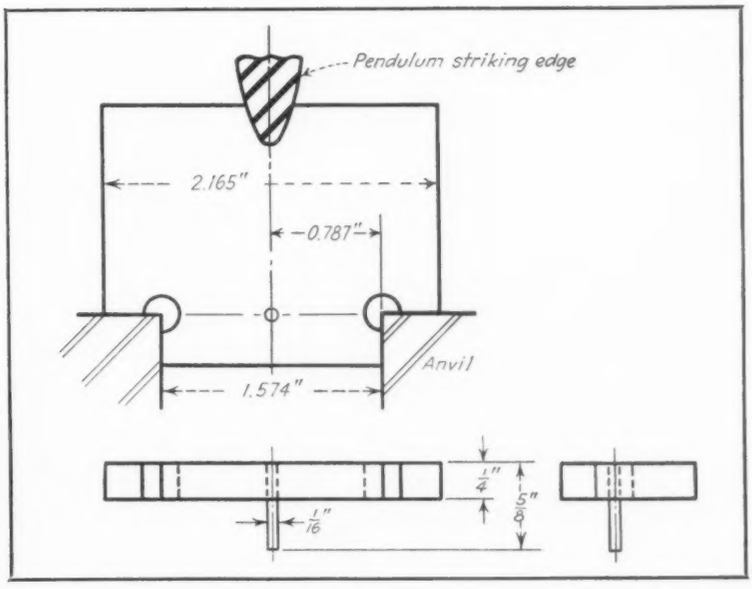


Fig. 9—A convenient locating jig that can be used for correctly aligning the pendulum, anvils and specimen in a Charpy testing machine.

Charpy and Izod Testing—II

C. M. SCHWITTER*

Formerly Major, Ordnance Department, Army of the United States
Watertown Arsenal, Watertown, Mass.

Charpy and Izod testing machines with the limits of reproducibility for test results. Discusses significance of impact tests, and industrial applications.

FOR a discusion of the types of Charpy and Izod test specimens refer to Part I, PRODUCT ENGINEERING, October 1947, page 106.

Testing Machines

No discussion of the variables which influence results would be complete without consideration of the testing machines as well. There are several varieties of Charpy and Izod equipment. A machine suited to one test is not generally adaptable to the other. Some directly measure the foot pounds of energy absorbed, others record the angle of swing of the pendulum and require conversion tables to translate results into terms of foot pounds. In both types, a common capacity of the machine is 120 ft.-lb.; at least one generally used make of Charpy machine has a maximum capacity of 220-ft.-lb. with a pendulum adjustable in height to deliver a specified energy of blow.

If bearings are kept properly lubricated there is little that can go wrong with either Charpy or Izod machines. It is occasionally necessary to check calibration; the anvil spacing of the Charpy type, which is adjustable, should be checked frequently. The pendulum should be aligned with centerline between the anvils and the specimen should be centered so that the knife edge of the pendulum strikes the specimen directly in line with the notch. Fig. 9 shows a convenient jig which can be used for aligning specimen, pendulum and anvils.

Reproducibility of Results

In reviewing the variables involved it becomes evident that for routine inspection purposes the impact test requires little more care and supervision than does the tensile or hardness test. First, it is necessary that the testing machine be in good condition, and that the measuring device read zero when the pendulum swings freely. Second, the specimen dimensions must be within the tolerances required by A.S.T.M. Specification E-23-41T. These tolerances are well within the practical limits of normal machine shop practice, and the only critical dimensions of importance are those of the notch; particularly the root radius. In the case of the keyhole notch, no special inspection is necessary other than to be sure that the right size drill was used. For the V-notch it is best to check the radius with a profilometer or to continually inspect the condition of the cutter. Third, the specimen temperature should be known or controlled at the time of rupture.

Information regarding the reproducibility of results obtainable with the Charpy test is shown in Table

* *The statements and opinions expressed are those of the author and do not necessarily reflect the views of the U. S. Army Ordnance Department.*

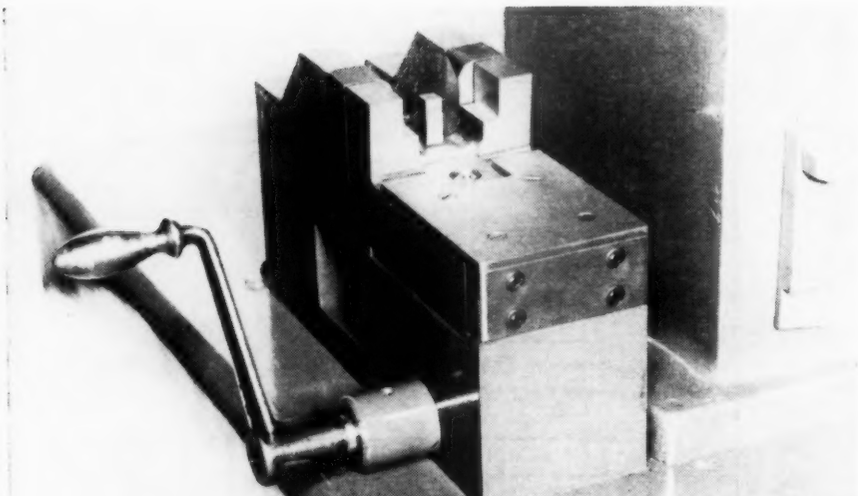


Fig. 10—Specimen set up for Izod test in combination impact testing machine.

Tinius Olsen Testing Machine Co.

Fig. 11—A drop test, performed by dropping a 200 lb. weight from 12½ ft on welded box beams held at —90 deg. F., differentiates between satisfactory and unsatisfactory materials. Note the bending of the satisfactory specimen marked 6, compared to the brittle rupture of specimen 4. After Herres.

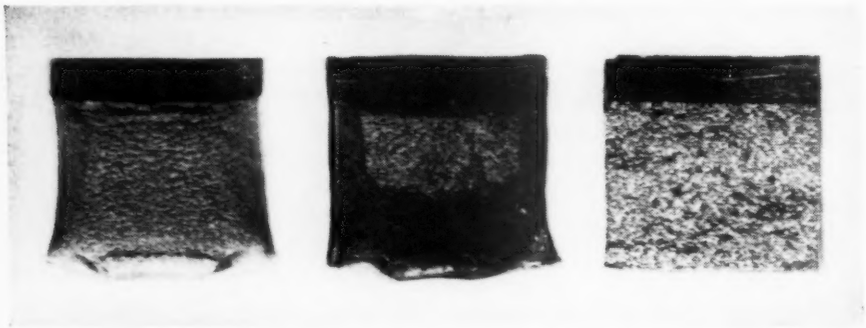


Fig. 12—Typical fractures of Charpy specimens with notch uppermost illustrating a "tough" fracture at the left in which appreciable fiber deformation occurred, and a "brittle" fracture at the right in which practically no fiber deformation occurred. The center specimen shows brittle characteristics only immediately below the notch and away from the edges of the transition-fractured specimen.

II (see Part I, October issue, page 109). In these series, all precautions regarding testing procedure were carefully observed. The scatter therefore indicates the combined effect of uncontrollable testing variations plus inherent variations in the materials themselves. It will be noted that on the basis of ten tests a spread of from 5 to 16 ft.-lb. can be expected, the greater spread occurring in materials of higher breaking energy. Extensive inspection tests on specimens, taken transversely in groups of four from alloy steel forgings of good quality, have yielded results within 2 or 3 ft.-lb. An occasional group had a spread as great as 6 ft.-lb. Statistical study based on a series of 50 or more specimens from a single forging gave results which indicate that for statistical purposes an extreme spread of approximately 14 ft.-lb. should be anticipated. None of these observed spreads indicate variations to a degree impractical for commercial acceptance testing.

Significance of the Impact Test

It is necessary to consider the meaning of the information obtained by impact tests and the ways in which such information may be utilized. There have been many instances in which materials judged satisfactory on the basis of tensile properties alone gave disappointing results in service, generally manifested as brittleness or susceptibility to stress concentrations. In circumstances such as these an impact test can be used to differentiate between satisfactory and unsatisfactory materials.

An example of difference in behavior under dynamic loading is shown by Fig. 11 from the work of Herres, *Journal of the American Welding Society*, March, 1945. It serves also as illustration of a typical drop test. The brittle nature of the failure of beam 4 is clearly evident as contrasted to the ductile behaviour of beam 6. These results could not be explained simply on the basis of tensile test results, but Charpy tests differentiated satisfactorily between the two materials.

To understand the lack of selectivity of the tensile test under such circumstances it is necessary to keep in mind that it uses a load applied in a uniaxial direction at a very

slow speed, and that it employs a specimen with fixed dimensions which may or may not bear relationship to the shape of the finished structure.

Experimenters noting that some materials, whose tensile tests gave indication of good ductility, broke in a brittle fashion under impact test, explained the difference in behavior by the greater rate of load application. Attempts to prove this hypothesis raised more questions than were settled, but it became evident that, if rate of load application was a factor, it was of considerably less importance than other considerations. The rate of load application in the standard notched bar tests is sufficiently low, when rated by physical standards, that these tests cannot be properly called impact tests, but would be more correctly designated as notched-bar bend tests.

It appears now that the multi-directional distribution and magnitude of the stresses largely determine behavior in the Charpy and Izod tests. Analysis of the stresses in a Charpy bar indicates that the stress system is exceedingly complicated and greatly different from the simple uniaxial stress developed in the conventional tensile specimen. At the root of the Charpy notch, stresses are concentrated and imposed in all three directions; the relative magnitudes of these stresses in relation to each other play an important part in determining whether the material being tested will behave in brittle or ductile fashion. It should be borne in mind that ductile behaviour occurs when the material is permitted to slip in shear. If this is not possible because the resistance to shear is high, either because of the inherent nature of the material or because superimposed stresses prevent slip along shear planes, the material will fail under pure tension, which prevents deformation and hence generates brittle failure.

In the conventional tensile test, the lack of restraint upon shear permits slip planes to develop readily and hence ductile failure is encouraged. In the Charpy test, or many of the other impact tests, a considerable restraint is imposed by the geometry of the specimen and by the transverse bending stresses concentrated at the notch; these combine to oppose slippage along shear planes and can thus induce brittle failure. The differentiation between brittle and ductile behavior is clearly illustrated by Fig. 12. In the specimen shown to the left there is evidence of ductility in the appearance of the fracture and the development of a "tongue" of deformed material at the bottom. The specimen at the right has a shiny crystalline appearance totally devoid of any evidence of ductility. The center specimen is an interesting example of a transition-type of fracture in which the restraint imposed by the geometry of the piece has been sufficient to induce brittle behavior at the center of the material beneath the notch; while in the areas around the edges of the specimen restraint has not been so severe and the material was allowed the opportunity to deform plastically.

The impact tests, then, whether they be Charpy, Izod or any of the special drop tests, measure the ability of material to adjust itself plastically to stress under a complicated system of combined stresses that cannot be duplicated by the standard tensile test.

In special tests, in which all or part of a built-up structure is subject to test, the stresses developed closely simulate those of actual service conditions, provided of course that the load is applied in the same direction and at the point expected in service. The Charpy and Izod tests, on the other hand, make no attempt to simulate service conditions but impose an arbitrarily fixed set of combined stresses upon speciments of standardized geometry. It is then necessary to postulate that, if the material behaves in a ductile manner and develops a high energy of rupture under the fixed set of test conditions, it will behave likewise under the conditions which are going to prevail in service. This analogy does not always follow. Sometimes conditions in service will be considerably more severe than those developed by the arbitrary test. Under such circumstances it may be useful to make the conditions of the impact test more severe, which can be done in several ways. The specimen size may be increased, the notch may be sharpened, the speed of testing may be increased or the temperature at which the test is made may be lowered. Such tailor-made conditions would serve as better criteria of serviceability in such instances than the arbitrary standard tests. Unfortunately current knowledge does not permit fixing the conditions of the impact test in advance; such adjustments require a trial and error method of approach and are of course limited by practical testing considerations.

On the other hand, it is equally possible that the conditions imposed by the standard impact tests are too severe for certain applications and that materials unsatisfactory by the standards of the Charpy or Izod test will behave perfectly well in service. In such instance the conditions of the test may be relaxed or the test can be omitted.

A practical philosophy of the usefulness of the Charpy and Izod tests is to consider them as a significant comparative tests for differentiating between materials and their general likelihood to develop tough or brittle behaviour. If the material is superior by these criteria, the least that can be said for it is that it is among the best materials available; failure in service suggests redesign of that part. By the same analogy, brittle behavior in the Charpy or Izod test immediately suggests that the material is far from being the best available and that, in the case of critically stressed or vital parts, something better might provide insurance against service failures. Experience will show how the test data are to be interpreted and will indicate changes needed in test procedure to meet service requirements.

Application of Impact Tests

The impact test has been very usefully employed commercially. Most obvious is its application to equipment operating at low temperatures such as pressure vessels employed for the storage and refining of petroleum and natural gas products. When these tests were first established it was argued by many engineers that, since a pressure vessel is not subject to impact loading, there was no need for meeting an impact requirement at the expected service temperature. This argument carried weight so long as the Charpy test was considered to reveal its information by virtue of its greater speed of application of load. When the concept of multi-directional stresses became generally recognized as the significant factor the

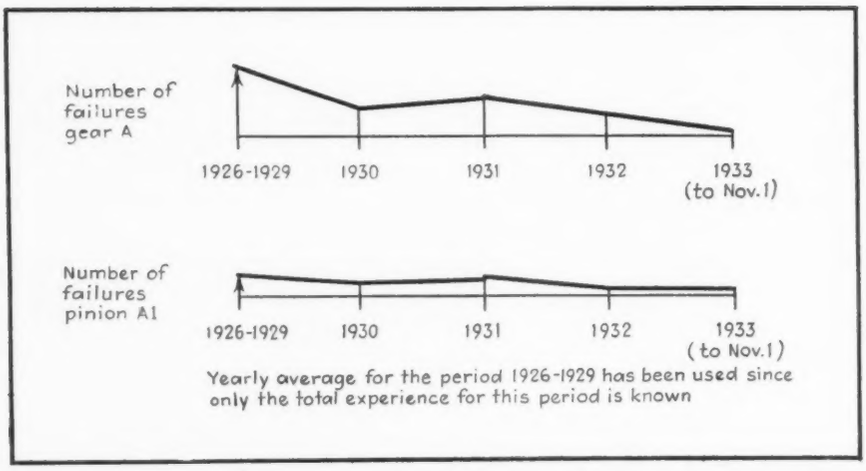


Fig. 13—Comparison of annual failures of tractor final-drive gears and pinions of S.A.E. No. 2345 steel shows steady improvement. After Riegel and Vaughn.

argument no longer applied, since most built-up structures are subject to this type of stressing even though subject to purely static loads.

Selection of spring steel material can be based on Charpy or Izod tests as well as static tensile tests. Springs are customarily heat-treated to relatively high hardness in order to produce high elastic strength; susceptibility to stress concentration effects resulting from scratches and surface imperfections is high. Springs are often used at sub-zero temperatures and occasionally receive shock loading. For these reasons materials which develop optimum impact resistance for a given elastic strength are often preferred; Keysor, PRODUCT ENGINEERING, November 1946.

Riegel and Vaughn, *A.S.T.M.*, Vol. 38, Part II, 1938, have cited many experiences concerning the utilization of the impact test to reduce failures in steel parts in which: "dynamic loading in service is not a part of the engineering consideration. Nevertheless, the freedom from failures is closely parallel to the classification made on the basis of the notched. bar test." Fig. 13 reproduces a chart from the authors' paper showing the progressive reduction in the number of failures of tractor gears and pinions where selection of steels was made on the basis of acceptance tests including a minimum Charpy value.

Similar experience is cited concerning certain cast steel tractor parts. The authors also mention success in increasing the hardness of tractor track links progressively from 302 Brinell to 444 Brinell, with the expectation of deriving considerable increase in wear resistance, without any reduction in the minimum Charpy values, thereby maintaining the same reliability in service.

Charpy and Izod tests will not replace other types of tests already in use but will provide supplementary information to aid in the proper selection of materials for specific design problems. As the fund of knowledge accumulates concerning the application and interpretation of impact tests they will be increasingly used.

REFERENCES

S. A. Herres "Weldability—Hot Rolled vs. Quenched and Tempered Construction Steels," *Journal of the American Welding Society*, March 1945.

Riegel and Vaughn "Practical Application of the Notched-Bar Impact Test," *Symposium on Impact Testing*, American Society Testing Materials, Volume 38, Part II, 1938.

H. C. Keysor "Carbon and Alloy Steel Materials for Hot-Formed Springs," PRODUCT ENGINEERING, November 1946.

Synthetic Lubricating Oils Developed

THREE SYNTHETIC OILS developed for the U. S. Navy for use in the ball, roller, and jewel bearings of delicate instruments are described in a report issued by the Office of Technical Services, Department of Commerce.

Development and research on the three oils was carried out at the Mellon Institute for Industrial Research between 1942 and 1946 under contract with the U. S. Navy's Bureau of Aeronautics to discover better lubricants for aircraft instruments. The report summarizes the early development of oils, and deals in detail with their improvement during the last year of the research.

One of the oils, called N-28j, is a light lubricant for use in instruments containing small ball or roller bearings. Having a very low pour point (minus 90 deg. F the oil works at very low temperatures. It is also satisfactory at high temperatures because of its low volatility and chemical stability. It has excellent rust inhibiting properties and does not corrode brass. It is not compatible with mineral oils or with solvents and cleaning fluids derived from petroleum products. Parts lubricated with N-28j should be cleaned with some aromatic material such as coal tar naptha.

The second oil, N-49w, is also designed for small ball or roller mechanisms that do not require a nonspreading lubricant.

The third oil, called N-54d, is nonspreading and is intended for use in the jewel bearings of watches, chronometers, and some types of flight instruments. Possessing unusually good lubricating properties, it gives a low coefficient of friction values between steel and jewel surfaces. Its most outstanding property is its viscosity at very low temperatures. Pour point is minus 90 deg. F, lower than that of any other oil with good nonspreading characteristics.

The report gives the chemical composition of each of the oils, lists their properties, and summarizes directions for preparing and blending them.

Orders for the report, PB-60970, (microfilm, $1; photostat, $3) should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D. C., and should be accompanied by check or money order, payable to the Treasurer of the United States.

NEW BOOKS

Experimental Stress Analysis

Proceedings of the Society for Experimental Stress Analysis, Vol. IV, No. II. 121 pages, 8½ x 11 in. Published by Addison-Wesley Press, Inc., Kendall Square, Cambridge 42, Mass. $6.

COLLECTION OF 12 PAPERS. Titles of papers with respective authors are:

Fatigue Tests of Major Aircraft Structural Components. W. G. Pierpont.

Precision Determination of Stress-Strain Curves in the Plastic Range. J. R. Low, Jr. and Garofalo.

A Method of Detecting Incipient Fatigue Failure. H. W. Foster.

A Machine for Fatigue Testing Full-Size Parts. A. F. Underwood and C. B. Griffin.

Some Repeated Load Investigations on Aircraft Components. S. A. Gordon.

Stress Analysis Utilization in Dynamic Testing. R. W. Brown.

Device for Maintaining Continuous Electrical Connections with Reciprocating Engine Parts. W. A. Wallace and W. A. Casler.

Evaluation of Various Methods of Rotor-Blade Analysis by Means of a Structural Model. R. Wayne.

Reluctance Gages for Telemetering Strain Data. W. H. Pickering.

The Linear Variable Differential Transformer. H. Schaevitz.

Design and Application of Accelerometers. D. E. Weiss.

Aircraft Instruments for Radio-Telemetering and Television-Telemetering. C. L. Frederick.

Servomechanism Fundamentals

Henri Lauer, Robert Lesnick, and Leslie E. Matson, engineering department, RCA Victor Division, Radio Corporation of America. First edition, 277 pages, 6⅜ x 9½ in. Published by McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 18, N. Y. $3.50.

Written primarily for the practicing engineer and engineering student, the book presents the principles, operating features, and systematic procedures for the design of servomechanisms. The procedures consist in determining the characteristics of component elements required, but the book does not discuss the design methods of components such as amplifiers, motors and gears.

A relatively detailed derivation is made of the basic characteristics of servo control devices and their relation to the physical principles governing their operation. Typical examples and problems are worked out, together with some test procedures to check performance of a servo system. Transient analysis aspects of elementary servomechanisms are stressed. Detailed solution of the differential equations involved are given; classical methods are used instead of more advanced processes of operational calculus.

The ten chapters discuss elementary control systems, follow-up links, fundamentals of mechanics and electricity, viscous output damping, error-rate damping systems, error-rate stabilization networks, integral control, transfer function, design calculations and general considerations.

The Book of A.S.T.M. Standards

Edition of 1946. *Almost* 7,000 *pages, 6 x 9 in. Published by the American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa. Set,* $44.

Because of the large number of pages necessary to cover the 1,400 ASTM specifications, tests, dimensions, etc., it was found necessary and convenient to split the 1946 set into five parts instead of the usual three.

The first volume, Part IA, contains about 225 specifications and tests, of which 150 relate directly to steel and steel products. The balance of the specifications in this part concern the rest of the ferrous materials and subjects.

Non-ferrous metals and their alloys are covered in Part IB With about 200 specifications and tests, this volume contains both standards and tentatives.

Nonmetallic materials used in the construction field are presented in Part II. This is the largest part of the 1946 Book and has over 300 specifications and tests. They cover all the phases of building materials and deal with paints, varnishes and lacquers.

In Part IIIA, the nonmetallic materials such as coal, coke, petroleum products, aromatic hydrocarbons and textiles are covered by about 200 specifications and tests. Almost 100 of these concern petroleum products, and 80 treat with textiles. Soaps and gaseous fuels are also located in this section.

While there is always new work going on in all phases of ASTM activity, Part IIIB includes more new standards and tests than the other volumes. There are groups of standards dealing with electrical insulating materials, plastics, rubber products, papers, adhesives and general testing methods. The work of the society in plastics and adhesives has been limited because the fields are relatively new, but many of the 250 specifications and test in this section cover intensive work in the rubber products and electrical insulating materials fields.

Each part of the 1946 Book of A.S.T.M. Standards has a complete subject index, and the various volumes can be purchased individually. There are two extensive tables of contents, the first lists all standards under general materials headings; the second according to the serial designations of the standards.

Fundamentals of Plastics

H. M. RICHARDSON *and* WATSON WILSON. 483 *pages.* 6 x 9 *in., clothboard covers. Published by the McGraw-Hill Book Co., 330 W. 42nd St., New York 18, N. Y.* $5.

This book is the outgrowth of a war training course on plastics, conducted for men in industry. The volume is divided into four parts. The first deals with certain fundamentals regarding the relation of chemical structure to physical properties. The second section discusses the six classes of plastics, devoting a chapter to each major group. The third section covers commercial methods used in the manufacture of plastics products. The last section deals with the evaluation of plastics, including their measurement and manufacturing control. Subjects covered include thermosetting condensation products, cellulosic plastics, vinyl polymers, rubber and the synthetic elastomers, polyesters and polyamides, and the silicones.

Guide to the Literature of Mathematics and Physics

NATHAN GREER PARKE III, *Research Associate in Physics Research Laboratory of Electronics, Massachusetts Institute of Technology.* 205 *pages,* 6 *x* 9 *in. Published by McGraw-Hill Book Company, 330 W. 42nd Street, New York* 18, *N. Y.* $5.

To make this guide of maximum usefulness in most reference work to engineers and applied scientists, the narrow limits of mathematics and physics have been exceeded. A considerable number of books have been included on aeronautical, electrical, radio, and mechanical engineering.

Part I contains a discussion of the principles of reading and study, and suggestions for self-directed education, literature search and specific aids that are available for periodical search.

Part II is a bibliography containing about 2,300 entries under some 150 subject headings. Under each subject heading is a paragraph or two delineating the subject, suggesting related headings, and sometimes singling out titles that will prove useful as a point of departure.

New Ozalid Streamliners Now Available For Immediate Delivery

Now, you can order—and promptly receive—a new, moderately priced print-making unit that gives you these 5 new advantages at no extra cost:

1. **SPEED.** In 25 seconds an Ozalid Streamliner reproduces your engineering drawings . . . or anything typed, drawn, printed or photographed on *translucent* paper.

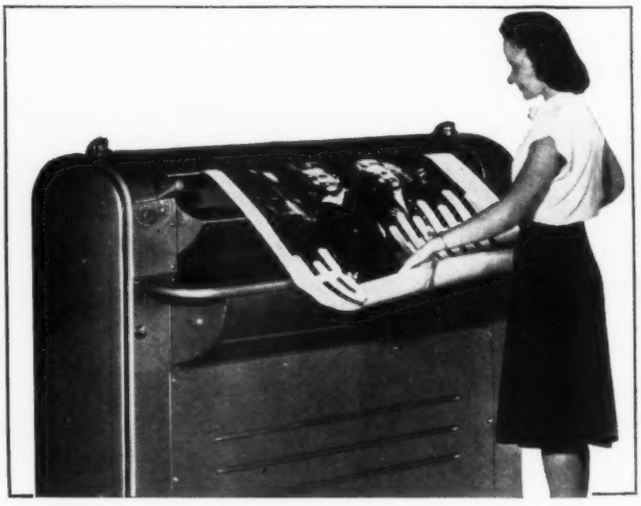
2. **EFFICIENCY.** You always get an exact-size positive (not negative) copy direct from your original . . . produced in 2 quick steps—Exposure and Dry Development.

3. **ECONOMY.** An 8½" x 11" print costs you less than one and a half cents per copy.

4. **VERSATILITY.** The lines and images on your original can be reproduced in black, blue, red, sepia, yellow . . . on paper, cloth, foil, film, or plastic.

5. **SIMPLICITY.** Anyone can be the operator. Place your original on Ozalid paper and feed into the Streamliner; that's 95% of the job.

Now an easy desk job. You remain seated, relaxed. All controls within easy reach. Prints are delivered on top, completely dry. Another advantage: You can install your Streamliner in any drafting room or office. Only 6 square feet of floor space is required.



A minute ago—engineering drawings. Now she's producing beautiful Ozalid Dryphotos in seconds, in exactly the same manner. Note the size: Ozalid prints can be up to 42" wide, any length. You can reproduce advertising posters, accounting reports—the work of all departments.

Expanded Production Facilities Now Permit Immediate Delivery

Thousands of Streamliners already installed. The following list is a typical cross-section of users:

Armstrong Cork Company
Bethlehem Steel Corp.
Bloomingdale Brothers
Bulova Watch Company
Chris Craft Corporation
Chrysler Corp.
Columbia Broadcasting System
Dun & Bradstreet
E. I. DuPont
General Electric Co.
General Motors Corp.
International Harvester Co.
Lever Brothers
Montgomery Ward Co.
New York Central Railroad
Northern Pacific Railway Co.
Pan American Airways, Inc.
Paramount Pictures, Inc.
Parke, Davis & Co.
Pittsburgh Plate Glass Co.
Remington Rand
Scovill Manufacturing Co.
E. R. Squibb & Son
Standard Oil Co.
Swift & Co.
Westinghouse Electric Co.

MAIL COUPON TODAY FOR FREE BOOKLET

DEPT. NO. 358

OZALID Division of General Aniline & Film Corporation, Johnson City, New York

Gentlemen: Please send free, 24-page, illustrated booklet . . . showing all of Streamliner's uses and 10 types of Ozalid prints.

Name_____

Position_____

Company_____

Address_____

Ozalid in Canada—Hughes Owens Co., Ltd., Montreal

Application Tables To Guide in the Selection of Materials—I

ZOLA FOX
Engineer, Rocket Section, Curtiss-Wright Corporation

THE NUMBER OF MATERIALS suitable for use by machine designers has been greatly increased during the last few decades. Many materials have some properties that are duplicated and it is often difficult for the inexperienced designer to decide which material should be used for a particular application. Strength is not the only criterion when choosing a material. Cost, availability, weight, ease of fabrication, and resistance to corrosion, fatigue, wear or high temperature are important considerations.

Specific materials, as indicated by their continued use, have been found particularly suitable for certain types of applications in machine design. The accompanying tables have been prepared so that the machine designer will have more information on which to base a judicious choice of materials. Since the field of materials is now so vast, no attempt has been made to completely cover all materials. The materials and applications listed in these tables are those used principally in machine design.

Under the "Remarks" heading will be found statements of limitation and of special properties that may influence the use of that material. When the remark is one of precaution, such as, "Do not weld", it is to be interpreted as indicative of present good practice and does not necessarily imply that a certain process cannot be used without resort to special methods or without an appreciable sacrifice in certain desirable properties.

WROUGHT CARBON STEELS

MATERIALS AND USUAL FORMS AVAILABLE	APPLICATIONS	REMARKS
SAE 1010-1015 Sheet, strip, rod and wire.	Auto body and fender stock, panels, deep drawings, sheet metal covers, cold headed parts such as tacks and rivets.	Low strength material not intended for primary components or structures. Poor machinability. Avoid threading. Does not respond to heat treatment.
SAE 1020–1025 (Machine Steel) Sheet, strip, bar, forging stock and tubing.	For carburized parts and general structural parts requiring no special properties. Small unheat-treated forgings, low strength shafting, wrist pins (low power engines), cam shafts, fan blades and tubing.	Poor machinibility though somewhat better than 1010. Readily welded and brazed. Bends easily. Not generally heat-treated except for case hardening.
SAE 1030–1035 Bar, tubing and forge stock.	Higher physical properties than lower carbon steels; for small and medium sized forgings as shackles, levers; cold forged fittings as screws and bolts; driving shafts and piston rods.	Responds to heat-treatment. Fair machinibility. Do not carburize.
SAE 1040–1045 Bar and forge stock.	Forgings such as crankshafts, connecting rods, starter ring gears, brake levers. Shafting, chain sprockets, large gears.	Tough, wear resistant and ductile. Shock resistant. Good hardenability. Small and intricate sections must be heat treated with care. Generally best to avoid thin sections in design. For greater strength and toughness use 3140.
SAE 1060–1070 Sheet, wire and forge stock.	Snap rings, clutch plates, bellville washers, lock washers, cushion springs, valve springs. For springs not subjected to severe service. For large forgings.	Compared to other spring materials, these steels have low elastic limit and fatigue strength. Has better formability in pretempered condition than higher carbon steel.
SAE 1095 Rod (called drill rod), sheet, strip and wire.	Pins, retainers, flat springs, clips, washers, motor springs, hot-formed spring, dowels, shafts and tools. Agricultural parts; harrow and seeder disks, rake and binder bundle carrier teeth.	Drill rod available in accurately ground diameters ±0.005 in. Sheet in spring temper is readily punched and blanked. Complicated springs must be formed with material in annealed condition and then heat-treated. Avoid stress concentrations and cold forming operations. Do not weld. Do not electroplate springs made of high carbon steel without special precautions to avoid embrittlement.
SAE 1112 Free-machining screw stock, rod and bar.	Screw machine products.	Unsuitable for parts subjected to shock, vibration or fatigue. Not recommended for forming, bending, upsetting or carburizing. Use where ease of machining and finish are prime considerations. Inherently brittle. For superior physical properties but similar free-machining characteristics, specify SAE 1315.

(*Continued on page* 167)

Rural Power Station

Kohler Electric Plants are built to withstand plenty of abuse in those out-of-the-way places where the going is likely to be tough and repair men are hard to find. Both industrial and domestic users have found they can depend on these self-contained units under the most difficult operating conditions.

Auto-Lite, with more than 36 years of experience, has the facilities, the testing equipment and the engineering know-how to build the right wire for the right job. This is why, for dependability, Kohler Engineers specify Auto-Lite magnet wire and high tension cable. No matter how large or small the requirement, Auto-Lite has a wire or cable to fill the need.

THE ELECTRIC AUTO-LITE COMPANY
Wire and Cable Division
Sarnia, Ontario Port Huron, Michigan

1500 watt Kohler electric plant . . . Auto-Lite equipped.

Tune in the Auto-Lite Radio Show Starring Dick Haymes — Thursday Nights, 9:00 — E.T. on CBS

CBS

AUTO-LITE *Electrical* **WIRE and CABLE**

Tables to Guide in the Selection of Materials (continued)

WROUGHT STAINLESS STEELS

MATERIALS AND USUAL FORMS AVAILABLE	APPLICATIONS	REMARKS
AISI 302, 304 Commercially called "18–8". Sheet, strip, bar, forge stock and tubing.	For equipment dealing with corrosive products. For heat exchangers, hospital and food processing equipment, pipe and pipe fittings, screws, bolts, and shafting. Hard-drawn wire is used for springs, aircraft and marine cable. Sheet stock in full hard temper is used in spot welded structures.	Non-hardenable by heat-treatment. Tensile strength and hardness may be increased by cold work. Non-magnetic with high corrosion resistance, ductility and toughness. Can be deep-drawn and readily spot welded. Do not use on wearing parts. Welds are strong and ductile, but must be made with care. For better machinability use type 303. Type 304 preferred for welded units.
AISI 303 Round, bar, forge stock and stainless drill rod.	Shafting, valves and pumps exposed to corrosive fluids. Aircraft instrument parts. Automatic screw machine products.	Good non-galling and non-seizing properties. High corrosion resistance. Free-machining stock. Non-magnetic. Welding not recommended. Retains strength at elevated and sub-zero temperatures.
AISI 410 Sheet, strip, bar, rounds, tubing and forge stock.	Valves and pipe fittings subjected to high temperatures (up to 850 deg. C.) or corrosive mediums, turbine blades and pump parts. Parts where paint is impractical. For decorative trim.	Good corrosion resistance. High strength. Hardenable by heat-treatment. Magnetic. Good machinability. Welds are brittle and must be annealed. Good creep strength. Does not scale appreciably to 1,400 deg. F. Subject to discoloration unless passivated. For better free-cutting and non-galling qualities, use type 416.
AISI 416 Bar, wire and forge stock.	For parts requiring considerable machining, corrosion resistance and high strength, but where impact resistance is not important. For carburetor parts, screws, pump parts and business machine parts.	Free-machining, heat-treatable, magnetic, non-galling stainless steel. Do not weld or use where high impact resistance is required. Do not heat-treat after fabrication due to non-uniformity of properties obtained. (Readily machined when hardness is 270–340 Brinell). Subject to discoloration unless passivated.

WROUGHT ALLOY STEELS

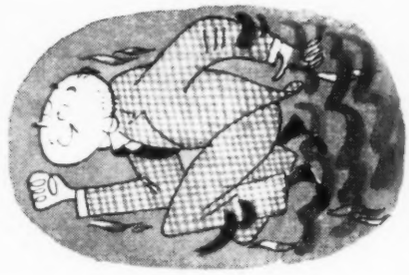
SAE 2317–2320 Bar and hexagon stock.	Gears, shafts, cams, pinions, universal joints, machine tool spindles and pump shafts. Parts to be case-hardened requiring a tough core, (piston pins and auto rear axle gears).	Principally for carburized parts in which only a small amount of distortion is permitted. Good machinability. Do not weld For higher fatigue strength use 3312, 3120, 4615 or 4620. For higher core strength use 2515 or 4615. For minimum distortion, higher wear resistance use 4615.
SAE 2512–2515 Bar and Forge stock.	For carburized parts requiring high core strength and toughness. Wrist pins, king pins, transmission gears, cams, rock drill parts, general machinery gears, engine starter gears. Heat exchanger tubes.	When carburized, case has exceptional wear and fatigue resistance. Free from scaling and distortion during heat treatment.
SAE 2330 Bar, rod and hexagon stock. Forge stock.	For highly stressed bolts, nuts, levers, turn buckles, generator shafts, heavy duty shafting, axles and rocker arms. Small parts subjected to torsion and fatigue. Large heavy duty parts where only simple heat-treatment is practical.	Very high impact strength and toughness. Cold-drawn stock has fair machinability and bright finish. Deeper hardening than corresponding plain carbon steel. Little heat-treat distortion. Do not carburize or weld.
SAE 3135–3140 Bar, rod, flats and square stock. Forge stock.	Aircraft, truck, bus crank shafts and connecting rods; intake valves; excavating machine parts; oil well tool joints, and steering knuckles. High temperature valves and fittings. Suitable for wearing edges in contact with non-metallic abrasives as in power shovels and farm machinery. 3150 used for small gears.	High impact and fatigue resistance. Suitable for parts subjected to heavy strains and vibration. Readily forged. Fair machinability. High creep resistance. Relatively low cost. Not recommended for machine parts subjected to severe metal-to-metal wear.
SAE 3310–3312 Bar and forge stock.	For forged parts requiring hard wearing surfaces and which are subjected to very heavy duty and high fatigue stresses. Used where reliability is essential. Aircraft engine gearing and shafts. Railroad, truck and bus gears and roller bearings. Differential gears and broaches.	Extremely high fatigue strength and wear resistance. Very high core strength. Not readily machined. Careful forge and heat-treatment required. Carburize for exceptional surface wear resistance. Air-hardening tendency adapts this steel to applications having large cross sections.
SAE 4130 (Chrome-moly steel) Bar, rod, sheet and tubing.	Aircraft fittings as control sockets, brackets and hardware. Structural frames of tubing. Widely used for welded units subjected to high stresses and not intended to be heat-treated after welding. Used in autos for axles and steering knuckles.	Mildly air-hardening in thin sections. Readily welded. High impact strength. Good machinability after heat-treatment. Shallow-hardening steel. Good physical properties with high ductility. Not recommended for parts of varying cross sectional thickness.
SAE 4140 Bar, rod, sheet tubing and forge stock.	Oil drilling, refining and mining tools; jaws, connecting rods, drill collars, shafting, bolts, high temperature valves and screw fittings. Heavy duty engine crankshafts, engine cylinder barrels, rear axles, spline drives, wrenches, hammers, aircraft forged fittings, heavy duty tubing.	High strength, wear and fatigue resistance; suitable for high and low temperature applications. Suitable for large sections because it can be deep-hardened. Good machinability. Weldability less than 4130. Suitable for parts of varying cross sectional thickness.
SAE 4340 Bar, rod and forge stock.	Auto and aircraft engine, diesel crankshafts and gears. Tractor rear axle drives. Medium sized forgings that can be quenched and drawn. Heavy duty shafting, machine tool arbors and screw driver blades. Large, heavy duty gears.	For large sections. Deep hardening. High strength and fatigue resistance. Good machinability at high hardness. Weld with care. Hardens in air, requires careful heat treatment.
SAE 4640 Bar and forge stock.	Transmission gears and splined shafts with sliding members. For shafts and parts requiring high fatigue resistance and physical properties. High strength studs. Medium sized gears for moderate service.	Uniform properties with good machinability. Little heat-treat distortion. High strength combined with very good ductility. Excellent wear resistance when cyanide dipped prior to quenching.
SAE 6150 (Chrome vanadium steel) Round and forge stock.	For heat-treated forgings and machined parts of high strength and fatigue resistance. For parts where variation in section thickness precludes proper and uniform heat-treatment. For gears, bolts, crank pins, worms, axles, hot-work punches and dies, leaf and coil springs. Suitable for springs subjected to elevated temperatures, high stresses and impact stresses.	High shock, wear resistance and excellent ductility. Very little heat-treat distortion. Stock very uniform and free of defects. Fine grain structure. Poor machinability. Do not weld.

(*Continued on page* 169)

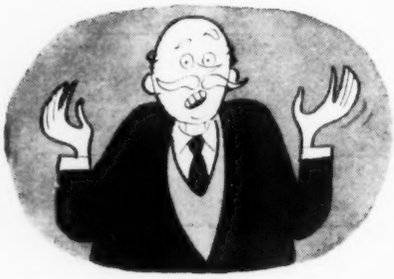
Sid was sick of shortages—so...

1. . . . he finally decided to convert to aluminum.

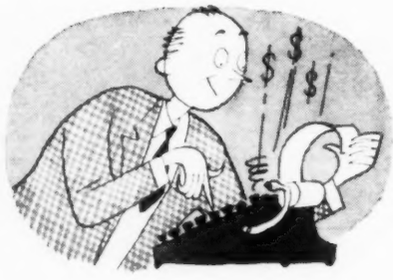
2. His competitor, Carl, just laughed. "Aluminum can't be adapted to Sid's product," Carl chortled.



3. But Sid was off like a fireball! For he'd learned that alloys of Kaiser Aluminum could meet almost every type of operation. And it could be formed, drawn, spun, brazed or joined.

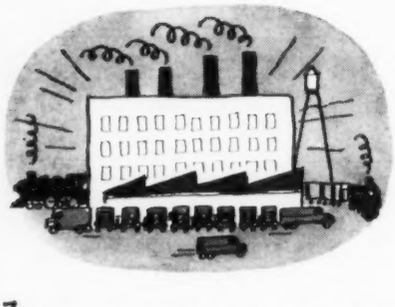


4. "So alright, he did it," shrugged Carl, "but the cost will break him."



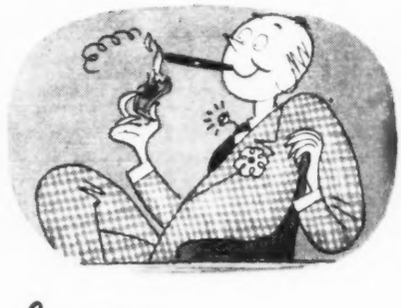
5. But foxy Sid found that though aluminum costs a little more to begin with, savings in handling, fabricating, finishing and shipping more than made up the difference.

6. Still, die-hard Carl wouldn't budge. No siree, he'd wait for the metal he had *always* used.



7. Meanwhile, Sid's product sold like popcorn at a circus. Folks preferred aluminum products. Result: Soaring production cut costs still further.

8. Now, would you rather be Carl?



9. . . . or Sid?

MORAL: Alert manufacturers — making everything from general appliances to residential buildings, from garage doors to heating and ventilating ducts — are speeding production, nailing down new markets . . . by converting to *Kaiser Aluminum*. The problems solved by them can help *you*. So call in a Permanente engineer *today!*

Ready to serve you—*today*...

Kaiser Aluminum

a Permanente Metals product

DISTRIBUTED BY PERMANENTE PRODUCTS COMPANY, KAISER BLDG., OAKLAND, CALIFORNIA . . . WITH OFFICES IN:
Seattle • Oakland • Los Angeles • Dallas • Wichita • Kansas City • St. Louis • Atlanta • Minneapolis • Milwaukee • Chicago
Cincinnati • Cleveland • Detroit • Boston • Hartford • Buffalo • New York City • Philadelphia • Washington, D. C.

Tables to Guide in the Selection of Materials (continued)

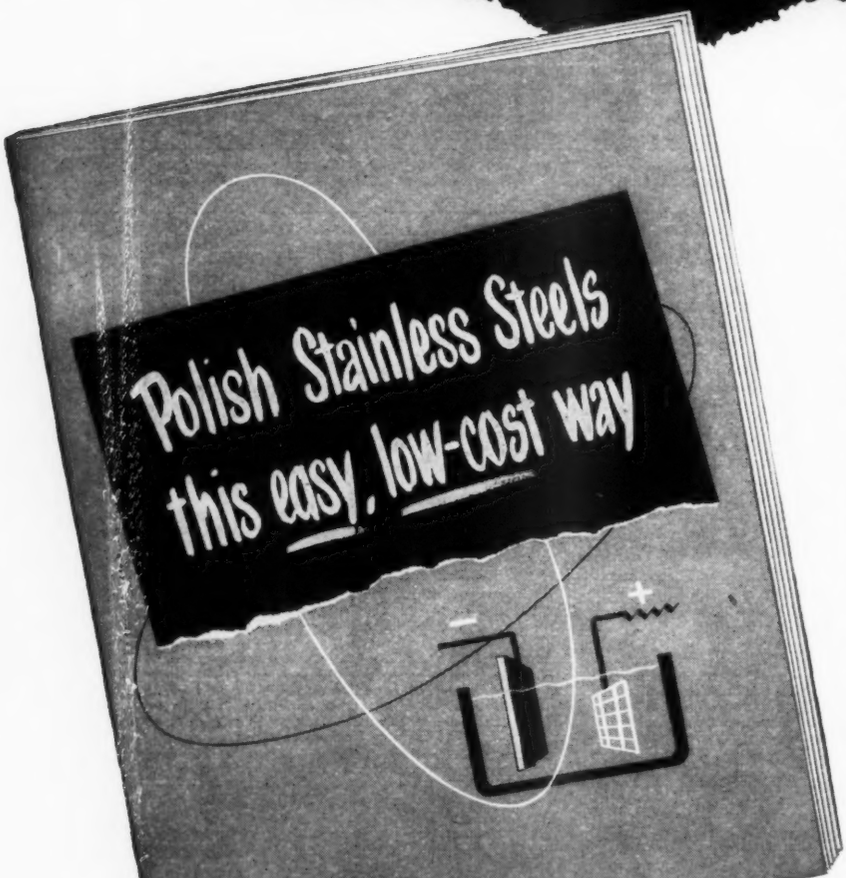
WROUGHT COPPER AND NICKEL ALLOYS

MATERIALS AND USUAL FORMS AVAILABLE	APPLICATIONS	REMARKS
Free Cutting Brass. Bar and shape stock.	Hydraulic fittings, electric terminal fittings, handles, automatic screw machine work. Where low stresses are encountered and where a large amount of machining is required.	Low strength, fast machining, bright finish and fair corrosion resistance. Poor malleability and ductility. Cannot be cold-worked. Welding not recommended. For better physical, cold-working and welding properties, but with about 70 per-cent machinability, use naval brass.
Commercial Bronze Sheet, strip and wire.	For stamped or drawn parts and for parts requiring extensive forming operations. For electrical sockets, conduits, flexible hose, condenser tubes and general hardware.	Excellent cold-working properties. Fair machinability. Good corrosion resistance. High ductility. Low strength.
Manganese Bronze Bar, plate, sheet and forge stock.	For parts requiring great strength shock and corrosion resistance. For bearings subjected to heavy duty, slow moving loads. For pump parts, valve stems, propeller blade bolts, fittings.	High strength and toughness. Poor cold-working properties. Fair hot-working properties, under some conditions, it is subject to season cracking. Not recommended for metallic arc welding. Machinability 30 percent of Free Cutting Brass.
Yellow Brass ("High" Brass) Bar and sheets in various tempers.	Soft temper for parts requiring deep-drawing, spinning or severe forming. Hard temper for flat springs and parts requiring only simple forming operations. For electrical sockets, clips, cartridge cases and eyelets.	Good strength and ductility, excellent cold-working properties. Fair machinability and corrosion resistance. Subject to season cracking. Can be welded and brazed. Do not hot-work.
Phosphor Bronze Sheet, strip, bar and wire. Available in various tempers.	For contact springs, helical springs, fuse clips, electrical contactors, lock washers, clutch disks, thrust washers. For small bushings, lead screw nuts, pump rods, bolts, valve stems and gears. For parts subjected to corrosion and wear.	High strength and toughness; excellent fatigue, corrosion and abrasion resistance. Low coefficient of friction. Machinability is fair (20 percent of free-cutting brass). Do not hot-work. Fair weldability; arc welding recommended. Not subject to season cracking. For similar applications but better formability, use Beryllium copper.
Silicon Bronze Plate, sheet wire, rod, tubing, shapes and forge stock. Available in various tempers.	Fastenings and electrical hardware for outdoor and marine equipment; heat exchangers, vats, pressure vessels, turn buckles, "U" bolts and corrosion resisting chain. For hot and cold forged parts.	High fatigue resistance. Strength comparable to mild steel. Excellent corrosion resistance. Readily welded and brazed. Some types have poor machinability. Difficult to forge.
Aluminum Bronze Sheet, rod, tube and forge stock.	Aircraft engine parts such as propeller hub cones, bushings, valve guides, spark plug thread inserts, valve seats and prop blade bolts; high strength, hard, gears and forgings.	Excellent resistance to scaling and oxidation at high temperatures and corrosive conditions. Light weight. Good cold-working qualities. Some types have poor machinability. Welding not recommended. Readily hot-forged. Some types can be heat-treated for improved physical properties.
Beryllium Copper Round, sheet, strip, wire and forge stock.	Springs, vibrators, diaphragms, electrical contact brushes, sylphon bellows, non-sparking tools, molds, appliance clips and switch blades. For parts requiring extensive forming and spring qualities as well as good electrical conductivity. Accurate instrument springs.	Readily formed in annealed state. Can be heat-treated to spring tempers. Heat-treatment must be done very carefully. High corrosion resistance. Cold work hardens material readily. Arc weld and low temperature braze only. Not readily machined after age-hardening. Grain direction for forming relatively unimportant.
Monel Rounds, sheet, strip, tubing and wire. Available in different tempers.	Valve and pump parts, turbine blades, laundry and food service equipment. Processing equipment. For marine and and aircraft instrument parts. For parts requiring exceptional corrosion resistance combined with high strength, hardness and impact resistance. For intricate and screw machine work as bolts and instruments, use "R" Monel.	Do not use under severe abrasive or galling conditions. Fair machinability. For free cutting quality, use "R" Monel. Non-heat-treatable. Arc welding recommended. Cold works readily when in soft temper.
Inconel Plate, sheet, strip, tubing, rounds, wire.	For parts subjected to very high temperatures, corrosive fluids and moderate stresses, as aircraft engine exhaust manifolds, carburizing boxes, nitriding hoods, heaters, piping and fittings and chemical processing vats and tanks.	Corrosion and oxidation resistant at high temperatures. Fair machinability. Readily arc, gas or spot welded. Non-magnetic. High impact strength. Galling tendency. Good ductility and deep-drawing properties.

WROUGHT ALUMINUM ALLOYS

2S, 3S Sheet, rod, extruded shapes and tubing in tempers O to H.	Piping, electrical conduit and junction boxes. Applications involving deep drawings, upsetting, spinning or welding. Fuel tanks, ducts and decorative trim. Low strength rivets. Not for primary structural applications. 3S is widely used for unfired pressure vessels.	Low strength, high corrosion resistance, soft, ductile and readily welded. Can be brazed. Non-heat-treatable. Variations in properties obtained by cold work. For greater strength, but less formability and weldability, use 52S. For general use specify ½ H.
24 S Sheet, rod, extruded shapes and tubing in tempers O, T and RT.	Lightweight primary structures, frames and fittings. Hydraulic fittings, hardware, rivets and screw machine products.	High strength, low weight, heat-treatable alloy. Do not weld. Not commercially brazed. Readily spot-welded. Can be moderately formed in non-heat-treated state. In contact with heavy metals as brass and bronzes, is subject to galvanic corrosion. Can be refrigerated after quenching to stop room temperature aging and hardening and to prolong time for forming. For better physical properties use 75S.
53S Sheet, rod, tubing, wire and shapes in tempers O, W and T.	Semi structural uses. Radio chassis, frames, household furniture and architectural materials. 52S-O is extensively used for hydraulic tubing.	Good formability, weldability and corrosion resistance. Heat-treatable, but physical properties are about 60 percent of 24S. For slightly better formability, use 61S.
75S, R-301 Sheet and extruded shapes.	For highly stressed members. For aircraft frames, coverings and fittings. For parts subjected to high fatigue stresses.	Has better formability in the "W" (as quenched, not aged) condition than 24S-T. Must be quenched in water. In "T" temper, has poorer forming qualities and notch sensitivity than 24S-T. Also has higher degree of springback than 24S-T. Can be welded by helium shielded arc but weld is not corrosion resistant and tends to be brittle. Spot welding satisfactory.
14S Extruded stock and forge stock.	High strength forged aircraft fittings and supercharger impellers; suitable for heavy duty applications requiring lightweight forgings.	Strongest of forged aluminum alloys. Good forgeability. For greater corrosion resistance with reduced physical properties specify 17S. For superior forgeability, A-51S or 25S. For parts subjected to elevated temperature, 18S.

EVERY PRODUCT-FINISHER SHOULD HAVE THESE MONEY-MAKING FACTS



WITH ARMCO ELECTROPOLISHING . . .
You can polish many kinds of stainless steel products to a high luster *in one operation* —without turning a buffing wheel!

WHAT IT IS . . .
This improved process is called "Armco Electropolishing." It is an easy, low-cost method of polishing many stainless steel products by anodic treatment in an electrolytic bath. The process has shown substantial savings for fabricators of practically all forms of ARMCO Stainless Steel . . . wire, bars, forgings, sheets and strip.

IF YOU PLATE . . .
If your products are made of plated metals it may pay you to investigate the possibilities of ARMCO Stainless Steels — and the Electropolishing process. Many manufacturers have cut costs and made good products better by changing over to Electropolished stainless steel parts.

MAIL THE COUPON TODAY . . .
For more information about this cost-saving method of polishing stainless steels, just fill in the handy coupon on this page. We'll send you a fact-filled folder on Armco Electropolishing titled "Polish Stainless Steels This Easy, Low-Cost Way." Mail it today! The American Rolling Mill Company, 333 Curtis St., Middletown, O.

ARMCO ELECTROPOLISHING PROCESS

ARMCO

MAIL THIS TODAY!

THE AMERICAN ROLLING MILL CO., 333 CURTIS ST., MIDDLETOWN, OHIO

Send me a copy of the folder "Polish Stainless Steels This Easy, Low-Cost Way."

Name _____ Title _____

Company _____

Street Address _____

City _____ Zone No. _____ State _____

NEW MATERIALS AND PARTS

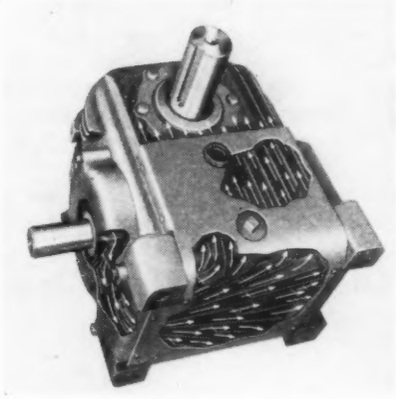
INDEX OF ITEMS

Product	Manufacturer	Page
Adapter, Flexible Shaft	F. W. Stewart Mfg. Corp	198
Amplifier, Direct Coupled	Amplifier Corp. of America	182
Assemblies, Lamp Socket	Drake Mfg. Co.	184
Bearing, Cam Yoke Roller	McGill Mfg. Co. Inc.	192
Caster, Airport	The Bassick Co.	200
Compass	Stewart-Jackson Instrument Co. Inc.	171
Control, Electronic Vacuum	Skaneateles Mfg. Co. Inc.	174
Control, Valve	Shafer Valve Co. Inc.	198
Conveyor, Chain	Island Equipment Corp.	184
Conveyors, Gravity Wheel	Sage Equipment Co.	188
Die Steels, High Impact	Latrobe Electric Steel Co.	206
Drive, Epicyclic	American Brake Shoe Co.	204
Drive, Feed-Traverse	General Electric Co.	174
Drive, Four Speed	Lima Electric Motor Co.	200
Drive, Pulsing	Yardeny Laboratories Inc.	196
Fixture, Rotary Piloting	Physicists Research Co.	172
Gage, Mechanical Pressure	W. C. Dillon & Co. Inc.	174
Idlers, Self-Aligning	The Jeffrey Mfg. Co.	186
Kit, Terminal Block	Curtis Development & Mfg. Co.	196
Motor, Precision Built	The Southern Cross Mfg. Corp.	178
Motor, Reciprocating Air	Bellows Co.	188
Motors, Small	The Alliance Mfg. Co.	202
Motor, Synchronous	Gleason-Avery Inc.	194
Oils, Silicone	Dow Corning Corp.	206
Oven, Electric	Trent Inc.	204
Pump, Rotary	Paul Engineering Co.	194
Reducer, Cone-Drive Speed	Michigan Tool Co.	171
Relay, Control	General Electric Co.	182
Strainer, Sediment	J. A. Zurn Mfg. Co.	174
Supports, Roller Pipe	Unistrut Products Co.	172
Switch, High Pressure	Cook Electric Co.	174
Switch, Pressure Operated	Meletron Corp.	178
Switch, Voltage Change	P. R. Mallory & Co. Inc.	190
Switch, Warning	W. C. Dillon & Co. Inc.	171
Tester, Stiffness	W. & L. E. Gurley	192
Thyratron	National Electronics Inc.	180
Thyratron, Heavy Duty	Federal Telephone & Radio Corp.	172
Timer Interval	Reliance Automatic Lighting Co.	172
Timer, Operation	Eagle Signal Corp.	186
Transmission, Variable Speed	Portman Machine Tool Co.	190
Valve, Safety and Relief	Farris Engineering Corp.	176

Cone-Drive Speed Reducer

Cone-Drive Div., Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.

The high horsepower transmitting capacity of these compact speed reducers is obtained because of the nature of the Cone-Drive gearing used. In this type of gearing, the number of teeth in contact varies directly with the number of teeth in the gear, the arc of contact being approximately 45 deg in all cases. With 24 teeth in the gear there are three teeth in contact; with 48 teeth in the gear, there are six teeth in engagement, each of which is half the size and area of the three teeth in the 24 tooth gear. As a result, very low unit loadings on the teeth are obtained. These units can be supplied with or without fan cooling, and can be altered after

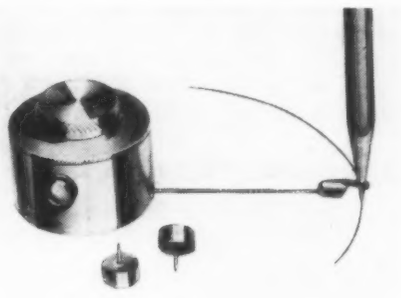


installation. The units are basically the same. The fan is attached to the standard pinion shaft and removable shields direct the fan-impelled air over the finned lower portion of the speed reducer housing. Equalized air-flow is obtained at all points of the housing that require cooling. The units are available with different center distances and horsepower capacities in 5, 10, 15, 20, 25, 30, 40, 50 and 60 to 1 ratios. The 5, 6 and 8 in. reducers are also available in a 70 to 1 standard ratio.

Compass

Stewart-Jackson Instrument Co. Inc., 815 Yale Ave., Los Angeles 12, Calif.

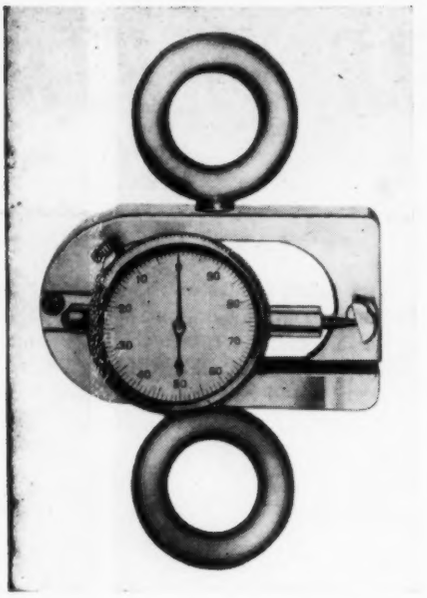
The Flex-A-Beam Compass consists of a stretch-proof linen line on an aluminum encased reel. Three special push-pins are furnished and serve as center points for the compass. A releasing button permits the line to be drawn out to whatever radius is desired. The linen line will hold true to any desired length, it is claimed. Circles from 2 in. to 12 ft in diameter can be made, and it is said that this instrument can be used to draw ellipses, spirals and arches.



Warning Switch

W. C. Dillon & Co. Inc., 5410 W. Harrison St., Chicago 44, Ill.

A versatile monitor that weighs loads up to 10,000 lb, the Dillon Dyna-Switch flashes caution signal, rings bell, and cuts out the hoist motor on chain or cable hoist and overhead cranes. Made of special alloy tool steel, it can be attached between overhead rail and hoist, or between hoist chain and hook in a few minutes. On cranes it is placed directly on the hook. After millions of stress cycles in test, it is claimed that the unit always returned to a true zero reading. It withstands accidental overloads, far in excess of the limit called



for by hoist or crane, without affecting calibration. The Dyna-Switch is made in the Basic model, with Motor cut-off; Visual model, with red caution lamp; and Weight model, in seven types from 0 to 100 lb, to 0 to 10,000 lb, with indicators showing 1 to 100 lb divisions. Switch is of the Burgess Micro-Switch type. The 3¼ lb switch is 7⅞ in. from top to bottom of eye bolts.

Heavy-Duty Thyratron

Federal Telephone and Radio Corp., 100 Kingsland Rd., Clifton, N. J.

A heavy-duty, mercury vapor thyratron tube operates both as a rectifier and as an instantaneous electrical circuit breaker. The grid design in this tube allows normal rated current to flow but blocks sudden overloads without damage to the tube or circuit. Designated Type F-5563, this tube is used as a voltage controller and overload protector in high voltage rectifier circuits for industrial heaters, transmitters and other high-voltage equipment. Of the negative-control, triode type, this tube operates on a filament voltage of 5v and a filament current of 10 amperes. The grid voltage for a typical installation would be minus 70 volts. With 15,000v peak, forward and inverse, anode voltage, the tube is rated at 1.6 amp average anode current.

Interval Timer

Reliance Automatic Lighting Co., Racine, Wis.

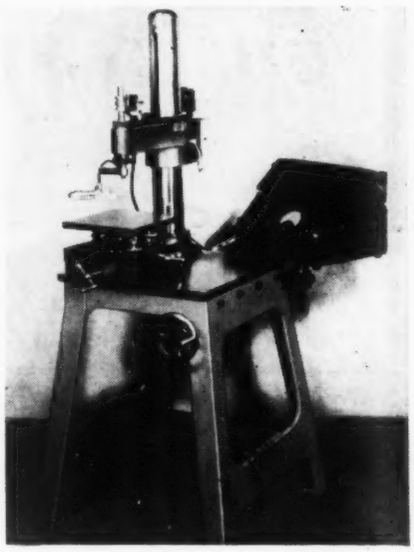
The Robotrol provides automatic and accurate control for varying industrial processes. A slow speed synchronous motor augmented by a precision gear train serves as the timing element for this unit. It has a quick-break switch with silver to silver contacts, and a cam and lever case-hardened to resist wear. The switch opens automatically when

the pointer returns to zero, but this unit is of the hand set, non-repeat type. Produced now with a 15 amp normally open switch, the Robotrol is available in production quantities in normally closed and double-throw switches in eight timing ranges. Ranges cover the 0-6 min and 0-12 hour spans, and can be had with capacities up to 25 amperes.

Rotary Piloting Fixture

Physicists Research Co., 321 S. Main St., Ann Arbor, Mich.

This Rotary Piloting Fixture is used for circular tracing with the Profilometer. This unit provides for taking microinch surface roughness measurements around internal and external surfaces of rotation such as cylinders, spheres and toroids, and on circular flat surfaces such as rings, grooves and

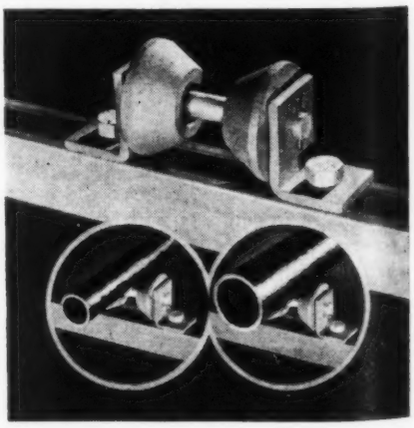


bosses. The work piece is held stationary while the tracing point is mechanically moved over the surface to be measured. The spindle is motor-driven; and to provide the same linear tracing speeds for all diameters of trace, a variable speed drive of extra-wide range is used. The length of arc traced is controlled by limit switches actuated by two adjustable collars on the upper end of the spindle. The spindle automatically reverses on reaching the limit set. The collars can be removed to permit continuous, complete spindle rotation wen desired.

Roller Pipe Supports

Unistrut Products Co., 1013 W. Washington Blvd., Chicago 7, Ill.

In the design of these pipe supports, the rings of the conventional solid rollers have been separated into two rollers with face slopes of 30 degrees. Rollers of the same size can be used with pipes of different sizes by changing axles. The axle is held by two brackets that are positioned on the horizontal framing. The frames are channels that permit the brackets to be anchored at any posi-



ON THE RAILS
Railroad bearings that provide the lowest cost-per-mile transportation with no sacrifice of efficiency.

ON THE ROADS
Automotive bearings that deliver smooth, dependable service over any type road without danger of failure.

IN INDUSTRY
Industrial bearings for pulverizing and steel mill equipment that give years of satisfactory performance with a minimum of attention.

Sleeve Bearings carry the HEAVY LOADS

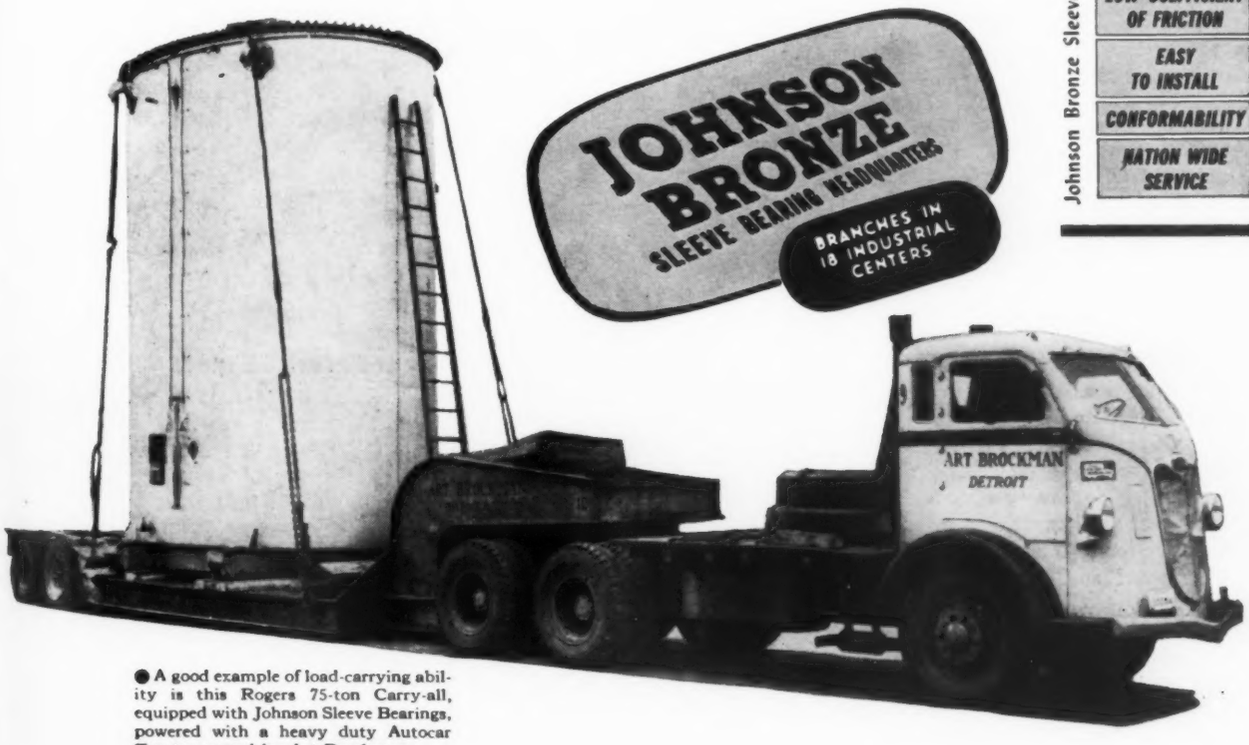
WHEN the application calls for *real load carrying capacity*, Sleeve Bearings are the first choice. This is particularly true when there is shock or impact . . . variation of speed . . . or vibration. The unit construction of a sleeve bearing distributes the load over a large, unbroken surface. This permits a continuous film of lubrication to form between the shaft and the bearing, preventing wear, reducing friction and acting as a cushion. Then, too, the load carrying capacity of sleeve bearings *increases* with the speed.

The easiest way to get sleeve bearings that will carry your loads . . . efficiently . . . economically . . . and for the longest period of time . . . is to call in Johnson Bronze. We can help you select the right bearing for each application . . . we manufacture your requirements to your exact specifications . . . and we deliver your order on *time*. Johnson Bronze Bearings are precision made, of high quality materials and low in cost. Why not write TODAY?

JOHNSON BRONZE CO.
508 S. Mill Street, New Castle, Pa.

Johnson Bronze Sleeve Bearings Give You Every Worthwhile Advantage

- LOW COST
- PRECISION
- QUIET
- LONG LIFE
- CORROSION RESISTANT
- UNIT CONSTRUCTION
- LOAD CARRYING CAPACITY
- HIGH RESISTANCE TO SHOCK
- LOW COEFFICIENT OF FRICTION
- EASY TO INSTALL
- CONFORMABILITY
- NATION WIDE SERVICE



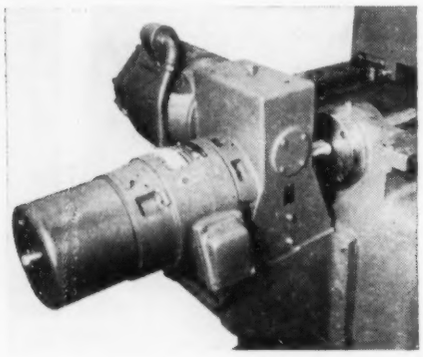
● A good example of load-carrying ability is this Rogers 75-ton Carry-all, equipped with Johnson Sleeve Bearings, powered with a heavy duty Autocar Tractor owned by Art Brockman.

tion. The vertical frames are channels of the same type. Because each of the components can be adjusted, the assembly is completely flexible. Piping runs can be aligned for a definite slope or for level flow. Rollers will carry pipes with outside diameters from one to 12 inches.

Feed-Traverse Drive

General Electric Co., Schenectady 5, N. Y.

Comprising an a-c traverse motor and a d-c feed motor packaged into one unit, this feed-traverse drive is used for machine tools. The drive provides a wide range of stepless feed and traverse speeds with close speed control. Both motors in the unit drive into a differential gear which has a single output shaft. The gear output shaft is so con-



structed that in many cases it can be coupled directly to the lead screw of the machine. The unit can be easily inspected and oiled without removing it from the driven machine. Control for the motors is standard and can be mounted wherever convenient. On developmental units, a traverse speed of 405 rpm was provided, and the feed speed ranged from 63 to 6.3 rev per minute. Feed speed ranges of 20 to 1, or greater, can be provided.

Electronic Vacuum Control

Skaneateles Mfg. Co. Inc., 122 Dickerson St., Syracuse 2, N. Y.

An electronic device, the type DM Skanascope Vacuum Monitor indicates vacuum pressures. Its signals are registered by high-visibility luminous tube units, connected in series with a pair of gage tubes that operate a rated 3 amp inductive load relay for the actuation of external apparatus. The gage tubes are of the "G" type, their common exhaust connection being arranged for optional metal-to-glass, rubber-to-glass, or direct glass weld-sealing. They are factory-calibrated to specification and function within close limits. Mate-

rials used in its construction are chosen to make possible the internal purging of the whole assembly by the use of a standard detergent. Components of the instrument are electrically connected with octal type sockets and plugs; they may be separated for panel mounting and other remote applications by the use of SMCI remote cables. This monitor operates in the 1 to 200 micron range.

High Pressure Switch

Cook Electric Co., 2700 Southport Ave., Chicago 14, Ill.

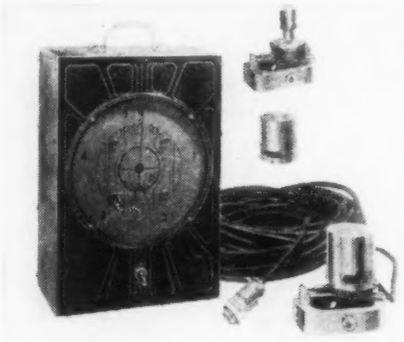
Designed for the control of high pressure hydraulic, air and steam systems, the Cook Hi-Pressure Switch can also be used to give warnings of system changes. The switching mechanism is housed in an impregnated aluminum casting. Pipe connection is solid brass with beryllium copper diaphragm brazed onto it. Diaphragm is heat-treated for proper spring rate and long life. Metal parts are cadmium plated where necessary. The contacts for this switch are inclosed snap action, single

pole, double throw type. The switches are factory-calibrated but include a calibration screw. They operate from 115 v a-c lines and have a maximum capacity of 10 amperes. These switches are available in the following pressure ranges: 5 to 50, 50 to 200, 200 to 500 and 500 to 2,000 lb per sq inch. The pressure differential between on and off position is approximately 10 percent of operation pressure.

Mechanical Pressure Gage

W. C. Dillon & Co. Inc., 5410 W. Harrison St., Chicago 44, Ill.

For measuring working loads in tight spots, the Dillon Remote Indication Pressure Gage shows mechanical pressure in vises, chucks, presses and mechanical assembles. It indicates tension in moving filaments and rods. The system is made with a Dillon Pressure Gage and two self-synchronous motors.



Transmitter motor is mounted on pressure gage needle axle. When load is applied, its electrical field is unbalanced. This unbalance is duplicated by the remote station repeater motor. The repeater motor can be located up to 300 ft away from transmitter. The gage and repeater are available in six ranges 0 to 100, 250, 500, 1,000, 2,500 and 5,000 pounds. Repeater cabinet contains two 6v dry batteries to supply the 12v current necessary for system operation.

Sediment Strainer

J. A. Zurn Mfg. Co., Erie, Pa.

Designed to meet the demand for an economical strainer in pipe lines where continuous flow is imperative, this duplex Sediment Strainer is of the quick-release type. When the strainer is to be cleaned, flow can be diverted from one basket to the other without interrupting passage through the strainer. The unit operates with a single plug type valve whose orifice directs flow from the inlet to either basket, or to both simultaneously. The seating of the plug into the

NEW HEAVY DUTY *Semi-Pneumatic* AIR KING TIRES

for puncture-proof service on portable and material handling equipment

AIR KING *Heavy Duty* Tires are FULL-cushioned, shock-absorbing, puncture-proof, non-skid, and wear-resistant. Modern techniques of engineering, manufacturing, and testing assure uniformly high standards of quality.

Among their wide diversity of applications, either as original equipment by manufacturers of wheel goods, or for replacement by owners of portable and material handling equipment, are the following typical applications:

Aisle Marking Machines	Cooling Fans	Paint Sprayers
Arc Welding Machines	Floor Sweeping Machines	Tote Trucks
Barrel and Drum Trucks	Hand Trucks	Traffic Line Markers
Battery Charging Machines	Hospital Equipment	Sidewalk Snow Plows
Car Washers	Insecticide Sprayers	Wheelbarrows
Contractors' Pumps	Lubricating Equipment	Misc. Portable Equipment

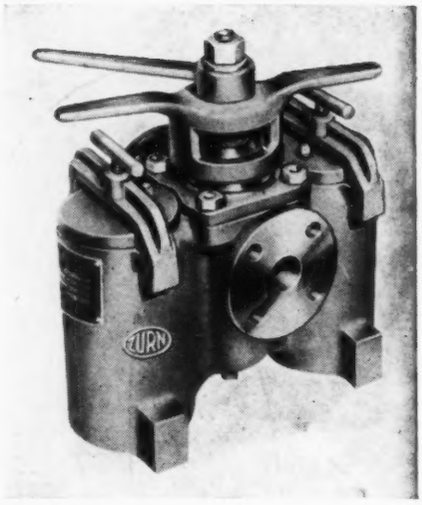
Standard sizes of *Heavy Duty* AIR KING TIRES range from 6" x 2.00" to 16" x 4.00" with respective load ratings from 150 lbs. to 625 lbs. per tire. Other sizes and load ratings made to specifications. There's an AIR KING TIRE to meet YOUR particular needs. Our representative in your area will be glad to discuss details. Write:

THE OHIO RUBBER COMPANY
WILLOUGHBY, OHIO

OHIO RUBBER CO

FACTORIES: WILLOUGHBY, OHIO • LONG BEACH, CALIF. • CONNEAUTVILLE, PA.
BRANCH OFFICES: DETROIT • NEW YORK • CHICAGO • INDIANAPOLIS • CLEVELAND • BOSTON

YOU
CAN
DEPEND
ON
Darnell
DARNELL
Casters & Wheels
If you want maximum floor protection, economy and efficiency Demand Darnell Dependability...Made to give an extra long life of satisfactory service .....
DARNELL CORP. LTD.
LONG BEACH 4, CALIFORNIA
60 WALKER ST., NEW YORK 13, N.Y.
36 N. CLINTON, CHICAGO 6, ILL.

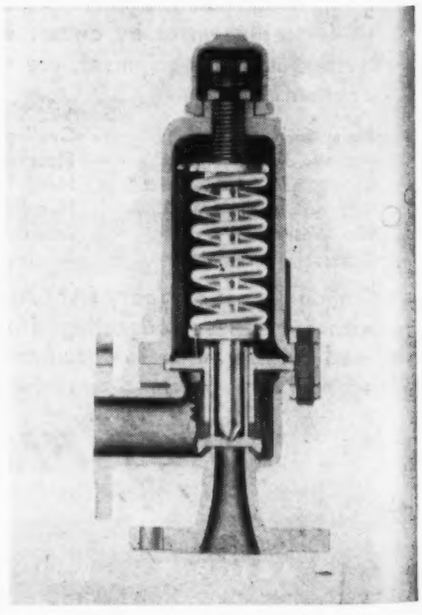


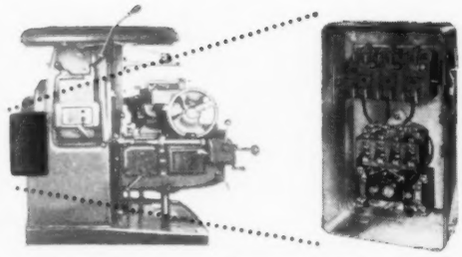
body is regulated by the relieving yoke which acts to seat the plug tightly for sealing, or to loosen it for turning, as required. Dual air relief valves are regularly furnished, available with flanged or screwed connections, and suitable for working pressures from 125 to 300 pounds. A basket chamber cover yoke assembly, or C—washer type bolted cover assembly is furnished as needed. Made of bronze, steel, and semi-steel or special alloys, the strainers are available in sizes from 1 to 6 inches.

Safety and Relief Valve

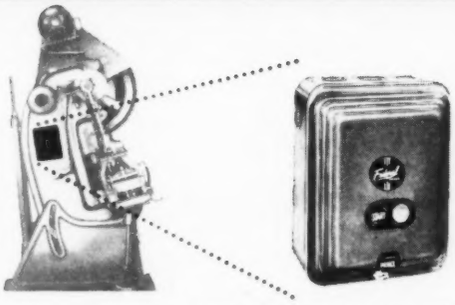
Farris Engineering Corp., 527 Commercial Ave., Palisades Park, N. J.

To be used in corrosive service, a line of safety and relief valves is said to resist the action of any of the acids or caustics normally handled on a commercial scale. Hastelloy-C is used for the inserted nozzle and the valve disk and, in certain models, for the complete valve body. This nickel-iron alloy containing molybdenum, silicon and copper, is hard and tough. The working parts

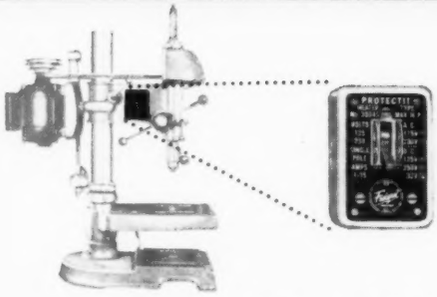




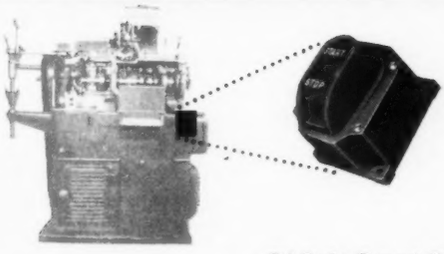
Combination Disconnect Switch and Starter



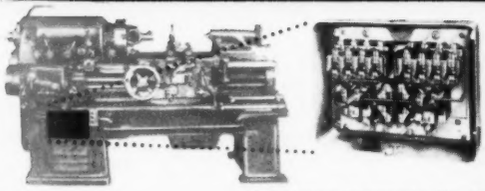
Magnetic Across-the-Line Starter



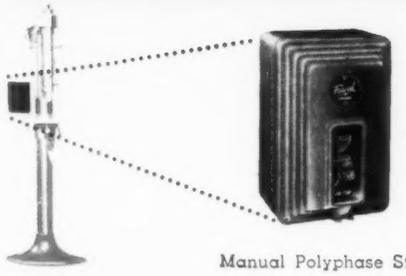
Manual Starter for Fractional H.P. Motors



Oil Tight Control Station



Reversing Magnetic Starter



Manual Polyphase Starter

"Take it from me—

a machine tool is only as efficient as its motor control"

"In a machine tool, it's performance that counts . . . and performance starts and stops with the motor control. When you can count on unfailing circuit protection against overloading . . . an instantaneous choice of automatic or manual reset—with a minimum of maintenance—you've got a piece of equipment you can depend on to stay on the job through the heaviest production schedule.

"That's why I always specify reliable Federal NOARK Motor Controls."

Get all the production-wise details from the nearest Federal Engineering Office now!

Federal NOARK

Federal NOARK MOTOR STARTERS

Federal Electric Products Company, Manufacturers of a Complete Line of Electrical Products including Motor Controls • Safety Switches • Service Equipment • Circuit Breakers • Panelboards • Switchboards • Bus Duct

Executive Offices: 50 Paris Street, Newark 5, N. J. • Plants: Hartford, Conn. Newark, N. J. St. Louis, Mo. L. I. C., N. Y.

NM Handbook

Just Off the press! Follow these directions and discover that the rich beauty of pre-finished Nickeloid Metals is not blemished by fabrication.

PRACTICAL SUGGESTIONS *for Fabricating* PRE-FINISHED Nickeloid PRE-PLATED Metals

● New, sixteen-page, illustrated handbook of practical fabricating suggestions of interest to all users and prospective users of pre-finished Nickeloid Metals.* Contains detailed instructions for successful handling of these beautiful metals — describes proper methods of BENDING, BLANKING, DRAWING, ETCHING, FORMING, RIVETING, SEAMING, SOLDERING, and WELDING operations. Contains general information relative to kinds, styles and patterns available in the famous NM line of metals . . . lists properties, sizes, weights, gauges, and conversion factors. Discusses typical uses and illustrates applications.

*Nickel, Chromium, Brass or Copper plated to Steel, Zinc, Brass, Copper or Aluminum — available in sheets and coils.

Yours For The Asking Fill out Coupon Below, Attach to Sheet of Your Business Stationery and Mail Today.

Free Handbook **AMERICAN NICKELOID CO., Peru 4, Ill.**

Gentlemen: Please send me a FREE COPY of the new NM FABRICATION HANDBOOK — describing practical methods of fabricating pre-finished Nickeloid Metals.

Name .....

Address .....

City ..... State .....

of the valve are isolated behind a vapor proof FarriSeal curtain. This protective seal is a flexible material attached to the disk at one end to the flanged disk-guide at the other. The material of the seal can be of rubber, neoprene or any corrosion resisting flexible metal. The valves are available with flange connections in sizes from ½ to 2 in., and with screwed connections in sizes from ½ to 1 inch.

Precision-Built Motor

The Southern Cross Mfg. Corp., 1029 Connecticut Ave., Washington 6, D. C.

Guaranteed to more than meet all NEMA performance requirements for motors of this type, this motor is designed for heavy duty continuous operation. The dynamically balanced armature rotation, life-time sealed and permanently lubricated precision ball bearings, plus close tolerances in all moving

parts, insure quiet efficient operation. The double fans, exposed laminations and ventilated end bells give a cool motor under load. These split phase motors are available with 3½ in. saddle strap mounts, standard NEMA base plates or base plates to specification. The motor, 10½ in. long, operates on 115v, 60 cycle current with a 40 degree heat rise. It draws 3.8 amp, has a speed of 1,725 rpm. and is reversible in rotation. The shaft of the ¼ hp model is ½ in. in diameter.

Pressure Operated Switch

Meletron Corp., 950 N. Highland Ave., Los Angeles 38, Calif.

The Model 310 switch is used as a control mechanism to be actuated by the pressure of liquids, air or gases. It operates as a high and low pressure limit switch. A Bourdon tube pressure response element can be adjusted to pressure gage accuracy and dependability. The switch is an approved snap action Micro switch. The unit is so designed that it will withstand surge pressures in excess of maximum working pressure without damage. The 310 switch is available in several combinations of switching and adjusting ar-

How We Beat Rising Costs by Changing to Welded Design

By Francis M. Wick, General Manager
Silver Manufacturing Company, Salem, Ohio

DESPITE the fact that costs have greatly increased in the past two years, the material costs of our "Ohio" Feed Cutter (Fig. 1) are no more today than on V-J day, due to the savings we have gained by changing to welded steel design.

The change to welded steel has also cut the machine's weight 24%, from 455 to 345 pounds—really a price decrease, since most of our sales are to foreign customers who pay duties assessed on basis of weight.

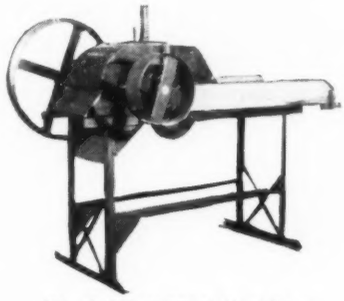


Fig. 1. The "Ohio" Feed Cutter.

We originally started experimenting with welded steel design because of the difficulty of getting a regular flow of parts. Our welding department has not only eliminated production bottlenecks, but has enabled us to increase production 79% with only a 20% increase in employees. The chief reason for this is that the parts of welded steel require much less machining, grinding and fitting than the former material. The same man-hours we formerly put into finishing now are used to prepare raw materials for the welding department and handle all finishing.

An example of cost reductions on the individual parts is the hood (Fig. 2). The hood made by the former method cost $1.99. We now fabricate it from three pieces of 12-gauge mild steel, flame-cut and brake-formed, for 94.3 cents, a saving of 52½%. Weight is also cut in half, from 17 to 8.5 pounds.

One of the interesting changeovers to welded design is the corrugated roll and shaft (Fig. 3). Weight was reduced from 18.5 to 11 pounds. The corrugated roll is now made of twelve angles, ⅛″ x 1″ x ⅝″. Six of them at a time are inserted in a special jig and tack-welded together to form a half cylinder. The end discs, stamped from 12-gauge sheets, are slipped over the shaft and held in position for welding in a cradle-type jig. Then, using another special jig, the two corrugated halves are tack-welded to the discs. Tack welds give sufficient strength.

Fig. 3. At left is former corrugated roll. New welded roll and shaft (center) are fabricated from steel shapes as shown.

Welding the shaft and roll as an integral unit eliminates the man-hours formerly spent in machining and broaching keyways—a troublesome job.

In redesigning the flywheel (Fig. 4), weight was removed from the center, where it has a low moment of inertia, and concentrated on the rim, where it has the best effect. Thus the welded steel flywheel weighing 56 pounds has the same efficiency as the former design of 72 pounds.

The flywheel O.D. is 24″. The rim is a 2″ x 1¼″ mild steel bar approximately 6′ long which is heated, rolled and welded. Spokes are 3/16″ x 2½″ bars, drilled and broached at the center to match the hub of cold drawn tubing spaced between them. Welding is done in a jig which has a center post to hold the spokes and tubing in alignment, and three jaws which center the rim around the spokes. Each spoke is welded to the rim with a single pass, and two large tack welds join the hub to the spokes.

Other parts we have converted to welded design are the side plates, pulleys and smooth roll. The frame, formerly bolted, is now arc welded. All welding is done with "Fleetweld 7" electrode.

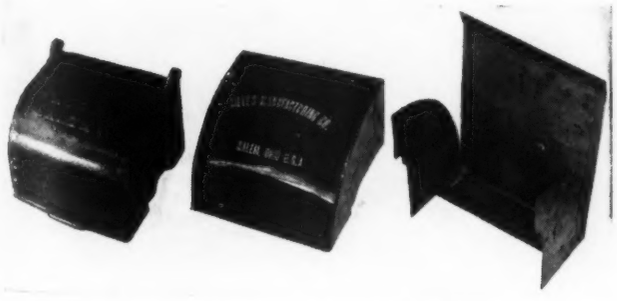


Fig. 2. Welded steel hood (center) costs 52% less than former design (left). How welded hood is made is shown at right.

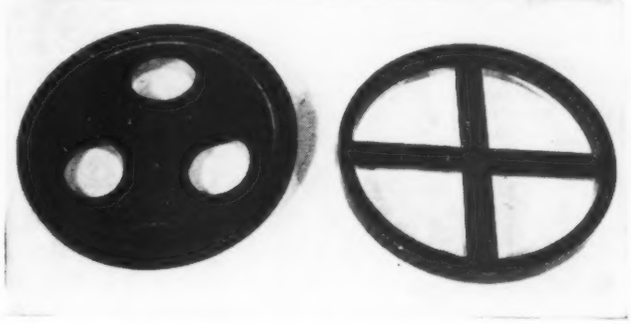
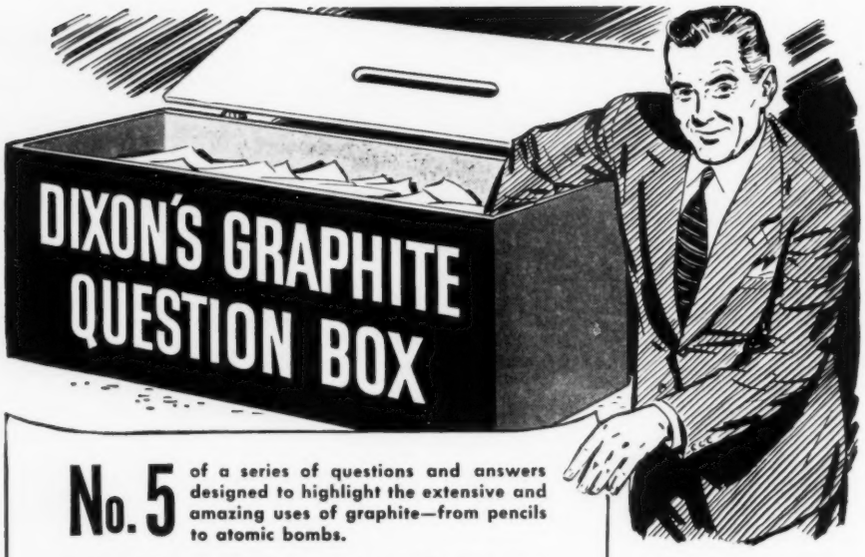


Fig. 4. The old flywheel was replaced by welded design (right) which weighs 23% less, but is just as efficient.

The above is published by LINCOLN ELECTRIC in the interests of progress. Machine Design Studies are available to engineers and designers. Write The Lincoln Electric Company, Dept. 368, Cleveland 1, Ohio.



No. 5 of a series of questions and answers designed to highlight the extensive and amazing uses of graphite—from pencils to atomic bombs.

HELPFUL ANSWERS FOR TECHNICIANS AND PRODUCT ENGINEERS

QUES. What are some of the qualities of graphite which have earned for it a reputation of being one of the most versatile minerals?

ANS. 1. As a lubricant it can be used in dry powdered form or as an additive, being available in particle sizes from 2 microns to large flake sizes containing particles from ⅓ to 2 millimeters.

2. It is available in concentrated form in various types of vehicles to produce suspensions for varying functions.

3. It can be incorporated in powder metallurgy processes to produce oilless bearings, and in iron powder metallurgy to produce preformed steel parts of high tensile strength.

4. It withstands excessively high and low temperatures, high pressures and operating speeds, and its chemical inertness makes it insoluble in all other known substances.

5. Graphite rates high as an efficient conductor of heat, as evidenced by its long and increasing usage in producing crucibles, retorts, molds and refractories.

6. Graphite is an efficient conductor and controller of electricity, resulting in its wide usage in producing self-lubricating motor and generator brushes, dry batteries, electrodes, resistors, television cathode tubes and other products in the electrical and electronic fields. Graphite is also widely used as an electrical conductor in electroplating processes.

7. Because of its resistance to chemical and temperature decomposition, graphite is widely incorporated as a pigment in protective coatings and paints.

8. Graphite adheres readily to other substances and materials but does not permit other substances to adhere to it. That is why its services as a coating or separator on foundry sand, aluminum and other types of molds are widely recognized.

9. Graphite is incorporated in steel to raise the carbon content.

10. Graphite, because of its heat-resisting qualities, is used in steel liquid hardening baths, and in somewhat similar techniques in the production of iron and steel.

11. Graphite is non-toxic and does not permanently stain or discolor other materials. Applied in some forms it produces a sleek, silvery, light-reflecting surface when rubbed or combined with transparent vehicles.

A few of thousands of widely used products containing Dixon's Graphites. Those starred are Dixon's products, many of them sold by supply houses everywhere.

★ Crucibles

★ Pipe Joint Compound

★ Graphite (pipe joint) Seal

Now may we receive *your questions* on how graphite can help *you*?

DIXON'S GRAPHITES

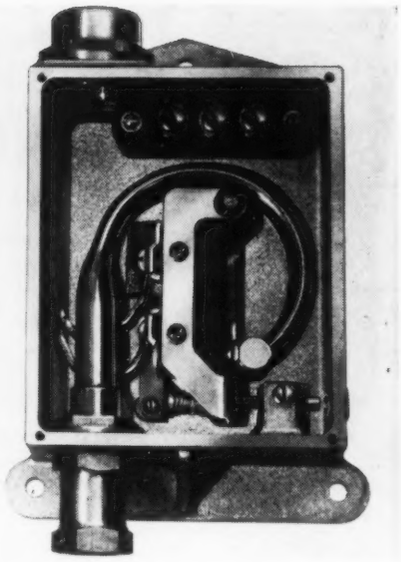
Products of

JOSEPH DIXON CRUCIBLE COMPANY

Jersey City 3, N. J. Div. 20-Q-11

LOOK FOR No. 6

in this series. We will gladly send you reprints of any you may miss.

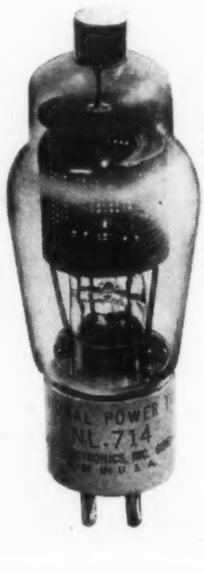


rangement: Single pole, double throw switch with standard adjusting screw for applications where relatively few changes in pressure setting will be required; manual reset type for safety applications where circuit is not to be re-energized until original cause of switch action has been determined; and both styles can be furnished with an external adjustment knob where frequent pressure setting is required. Switches are available for systems with 500, 1,500 and 3,000 psi maximum pressures. The adjustable ranges of the various sizes cover 15 to 50 psi minimum on decreasing pressures, and 400 to 2,500 psi maximum on increasing pressures. The differential pressures range from 8 to 275 lb per sq inch.

Thyratron

National Electronics Inc., Geneva, Ill.

The National thyratron, NL-714, is an industrial tube designed to give quick stability to timing circuits even at low temperatures. It is interchangeable



for the beating an iron cord bushing gets...

Perbunan can "take it"!

PERBUNAN
REG. U. S. PAT. OFF.

THE RUBBER THAT RESISTS OIL, COLD, HEAT AND TIME

Enjay Company, Inc., 15 West 51st Street, New York 19, N. Y.; First Central Tower, 106 South Main Street, Akron 8, Ohio; 221 North LaSalle St., Chicago 1, Illinois; 378 Stuart Street, Boston 17, Massachusetts. West Coast Representatives: H. M. Royal Inc., 4814 Loma Vista Avenue, Los Angeles 11, California. Warehouse stocks in Elizabeth, New Jersey; Los Angeles, California; Chicago, Illinois; Akron, Ohio; and Baton Rouge, Louisiana.

Copyright 1947, Enjay Company, Inc.

The spot the cord enters the electric iron is where a rubber bushing takes a beating! It must withstand intense heat . . . constant flexing . . . moisture from steam irons . . . and rough-pull usage.

In introducing its post-war steam iron the SILEX COMPANY wanted an *improved* bushing to meet these requirements. Their engineers worked with the research development men of the ACUSHNET PROCESS COMPANY and, after careful testing, *a Perbunan cord bushing* was selected.

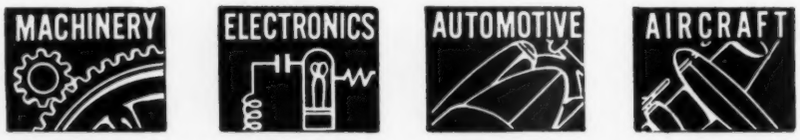
HERE'S WHY: Perbunan nitrile rubber *more than meets* the rigid tests of the Underwriters' Laboratories . . . and provides exceptional resistance to deterioration from heat, moisture, aging, flexing and rough handling.

Perbunan also has a new color stabilizer that keeps even the most delicate shades constant . . . with no discoloration of the fluids or materials it contacts.

Whatever rubber problem you may have, our experts will gladly help you solve it. Please write to our office nearest you.

FLEXIBLE SHAFTS

Wherever power drives or remote control are required, you can depend upon us to produce the Flexible Shafts that will meet the exact specifications. We have years of experience in manufacturing flexible shafting for all types of industry. If we do not have what you require in stock, we can make shafts to your specifications. Our engineers will be glad to work out your problems without obligation.



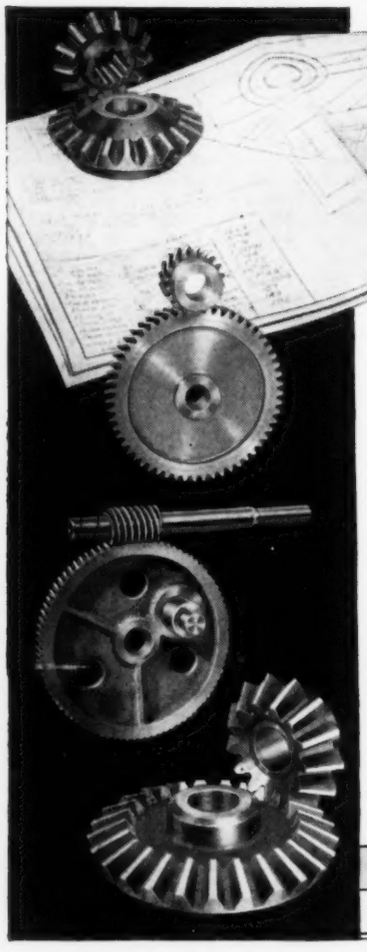
Many new uses for flexible shafts that carry power around any corner have been developed by our engineers . . . in machine shops, electronic, automotive, aircraft, in all industries where power drives or remote control are required. ***Write for Manual P. E.***

CIRCLE

F. W. STEWART MFG. CORPORATION

4311-13 RAVENSWOOD AVE. CHICAGO 13, ILL.

WEST COAST BRANCH: 431 Venice Blvd.; Los Angeles 15, Cal.



WE TURN BLUEPRINTS into Action

Precision Gears Made to Your Exacting Specifications

When Sewall craftsmen go to work on your specifications, you are employing the extensive facilities of an experienced organization. Our engineers can give you valuable assistance in establishing the *one best design*—then in turning out uniform production runs. Illustrated are examples of a Sewall bevel gear and pinion . . . worm and worm gear . . . helical gear and pinion . . . Zerol bevel gear and pinion. *Send blueprints or samples for prompt estimates on any quantity.*

RACKS • SPROCKETS • SPUR • SPIRAL • BEVEL • ZEROL BEVEL • WORM GEARS

E. B. SEWALL MANUFACTURING CO.

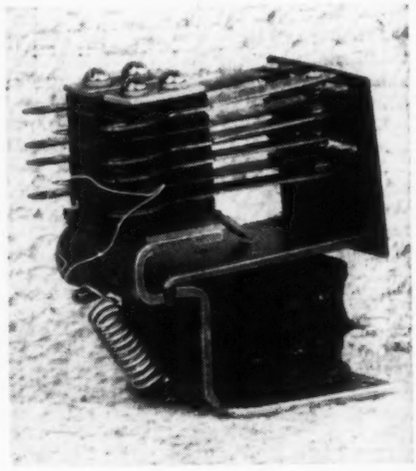
696 Glendale St. St. Paul 4, Minnesota.

with the 5557/FG-17 and gives immediate stability of grid characteristics because of the inert gas filling in addition to the usual mercury. The arc drop is 15 v with the maximum instantaneous output of 3 amperes. The maximum peak voltages, inverse and forward, are 1,250 volts.

Control Relay

General Electric Co., Control Div., Schenectady 5, N. Y.

A two-circuit relay designed for use on appliances and vending machines minimizes the effect of dust and fatigue with large rocker bearing and ample contact pressure. All ferrous parts are protected against corrosion. The molded



phenolic insulators have stable dielectric strength and provide 1/16 in. creepage between adjacent contact springs, as well as ample insulation to the ground. The relay can be mounted by any two of the four tapped holes in the base and occupies a space of three cubic inches. This relay is available in 5 amp. 115ov a-c 5 amp. 24v a-c ratings.

Direct Coupled Amplifier

Amplifier Corp. of America, 398-13 Broadway, New York 13, N. Y.

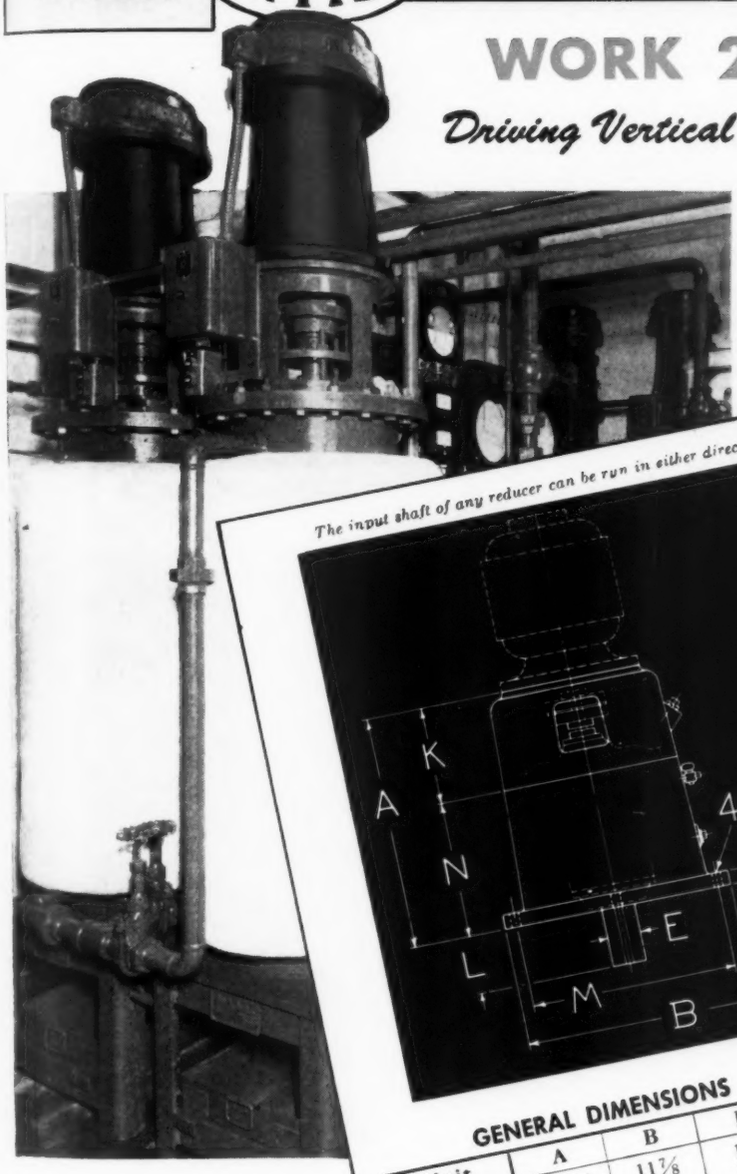
This amplifier is equipped with a built-in low-noise and low-hum pre-amplifier and fixed pre-equalizer to fully compensate for the characteristics of the G.E. Variable Reluctance Magnetic

THESE NO. 20V

WHS VERTICAL *Differential* SPEED REDUCERS

WORK 24 HOURS A DAY

Driving Vertical Mixers for Vegetable Oil Refining

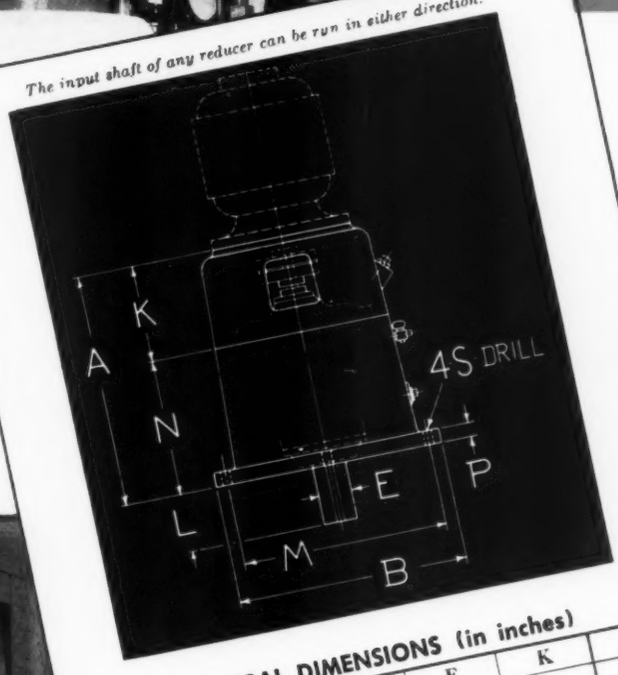


This DeLaval Separator Company installation . . . in Cudahy Packing Company's Leewood Refinery at Memphis, Tenn. . . . . incorporates a battery of WHS Vertical Differential Reducers, each reducer with a ratio of 3.09:1 and powered by a 5 H.P. motor. They were selected for their

DEPENDABILITY

as well as for their compactness, ease of installation and simplicity of mounting. The slow speed shafts are directly coupled to the mixers with a gear flexible coupling.

The input shaft of any reducer can be run in either direction.



GENERAL DIMENSIONS (in inches)

Unit	A	B	E	K	L
7V	12 5/16	11 7/8	1 1/4	5 15/16	2 5/16
10V	14	13	1 1/2	6 3/4	2 1/2
20V	16 1/16	15 3/8	2 1/16	7 3/4	3 1/2
30V	18 1/4	18 1/8	2 5/8	7 5/8	4 1/2
40V	21	21 1/2	3 3/16	8 1/4	5 1/2
50V	24 5/16	26 1/8	4	9 1/4	6 3/4
60V	32 7/8	39	5	14 1/2	6 1/8

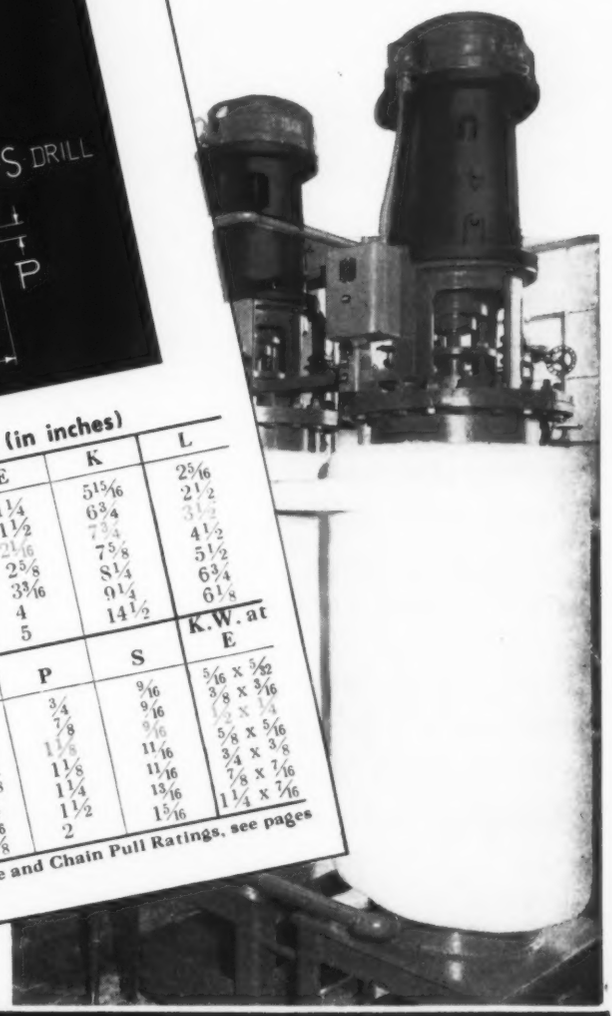
Unit	M	N	P	S	K.W. at E
7V	10 5/8	7	3/4	9/16	5/16 x 5/32
10V	11 1/2	7 1/4	7/8	9/16	3/8 x 3/16
20V	13 7/8	8 5/16	1 1/8	9/16	1/2 x 1/4
30V	16 1/4	10 1 5/8	1 1/8	11/16	5/8 x 5/16
40V	19 1/2	12 3/4	1 1/4	11/16	3/4 x 3/8
50V	23 3/4	15 1/16	1 1/2	13/16	7/8 x 7/16
60V	33 3/4	18 3/8	2	1 5/16	1 1/4 x 7/16

NOTE: For Horsepower, Torque and Chain Pull Ratings, see pages 82-95.

WHS PATENTED Differential Helical Gear Speed Reducers provide any ratio of reduction from about 3 or 4 up to many thousands to 1 . . . in a single stage and in the same housing.

They are fully illustrated and described in our pocket-size Catalog No. 147. Send for a copy. It also includes valuable engineering data.

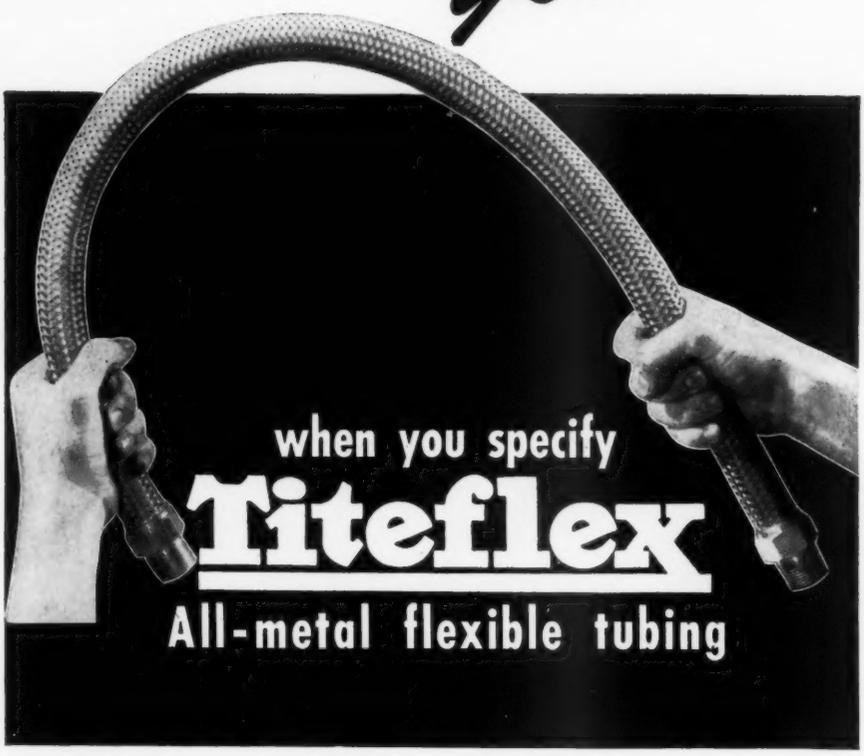
MEMBER OF AGMA



WINFIELD H. SMITH CORPORATION

111 EATON ST. . . . SPRINGVILLE . . ERIE COUNTY . . NEW YORK

Progress in design is *yours*



Titeflex is keeping pace with the latest designs of machinery and industrial equipment.

TITEFLEX is constantly developing new types of all-metal flexible tubing. Tubing fabricated from brass, monel, stainless steel, and various other metals are available for any application demanding flexibility, high temperature, high pressure, corrosive resistance, tightness, vibration, or downright abuse.

Difficult plumbing and pipe installations are eliminated when Titeflex is specified for the job. Elbows, bends, and fittings that have to be attached to straight lengths of tubing are no longer necessary. A unit in itself, Titeflex is easily installed. A few quick turns on a wrench and the most complicated installation job is accomplished in a few minutes.

Titeflex has a proven record of performance for more than 30 years. Problems of any type installation are invited without obligation.

Titeflex, Inc. 518 Frelinghuysen Ave., Newark 5, N. J.

Exclusive Manufacturers of Titeflex high quality products for more than 30 years

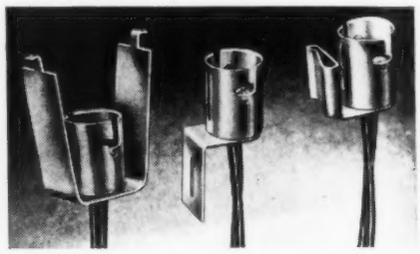
Sales Offices { CHICAGO CLEVELAND DETROIT PHILADELPHIA LOS ANGELES BOSTON SAN FRANCISCO TORONTO

Pickup it is designed to accommodate. It contains, in addition, a variable High Frequency Equalizer for compensation of pre-emphasized recorded and radio programs, as well as a Low Frequency Equalizer for full compensation of constant amplitude recordings. Filtered d-c, having less than 0.03 percent ripple is applied to the heaters of the input tubes. Scratch and distortion are kept within very close limits. Plate voltage is automatically applied within 20 sec after the unit is first turned on.

Lamp Socket Assemblies

Drake Mfg. Co., 1713 W. Hubbard Blvd., Chicago, Ill.

Double contact candelabra bayonet type socket assemblies for housing household type lamps are approved by the Underwriter's Laboratory for 75 w, 125 v service. Bulbs are not loosened from

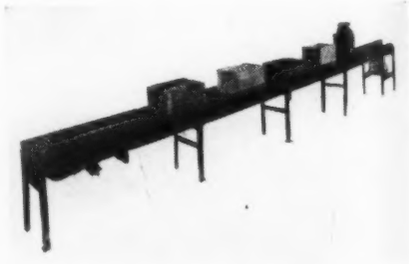


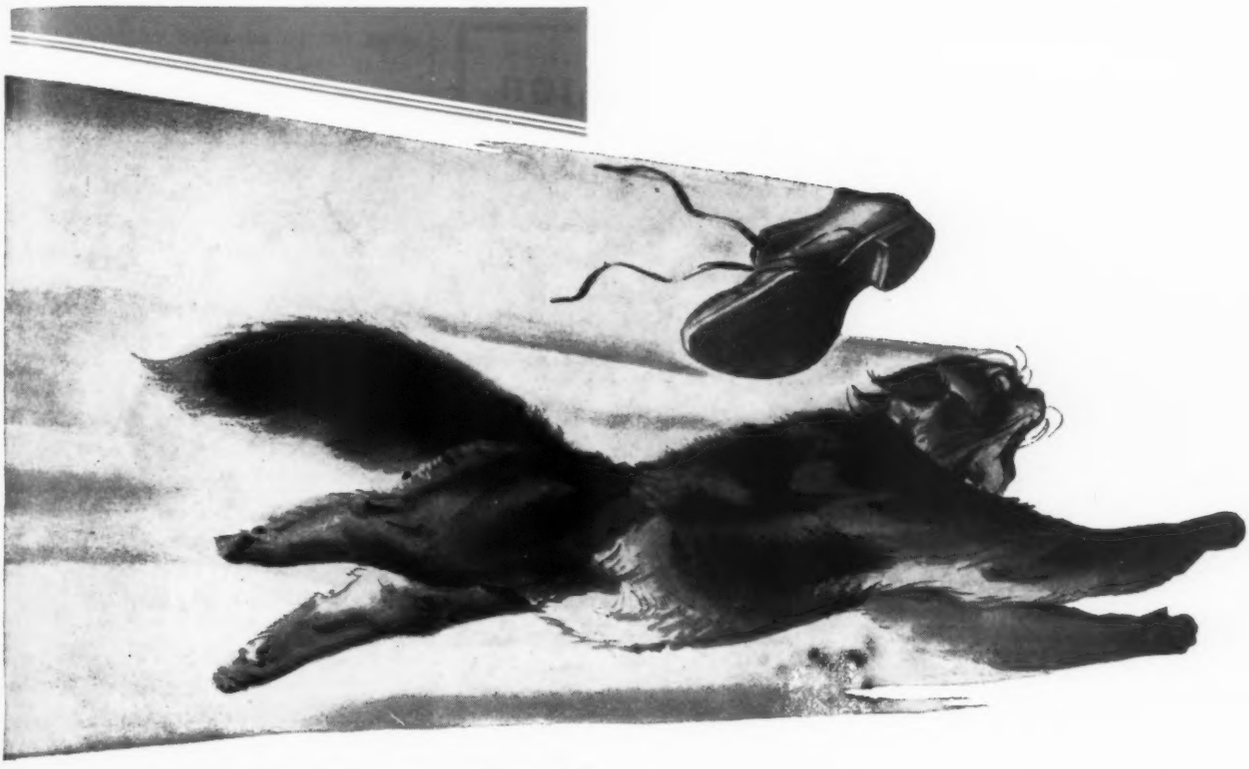
these sockets by mechanical vibration. Sockets are available with factory-installed leads from 2½ to 60 in. in length. These sockets are supplied with any of ten stock brackets, or can be equipped with brackets of special design. Designed to occupy little space, these sockets can be used in radios or general household appliances.

Chain Conveyor

Island Equipment Corp., 101 Park Ave., New York 17, N. Y.

A self-contained conveyor that can be used in conjunction with other systems, the Double-Flex Chain Conveyor has specially designed links. The tops of the links form a broad, flat carrying surface and the sides are smooth and flat to minimize guide wear at turns. The links are cast from special alloy steel and are pin-assembled. Tension adjustment is made at the idler sprocket where the chain reverses direction. The idler is attached to a double sliding arm





MAKE 'EM RUN
Like a Scared Cat!

There's nothing like a NORGREN LUBRICATOR to make air cylinders on production machinery operate with smooth, silent, flashing power!

Automatic. Injects exactly the correct amount of oil into the air stream to lubricate—with a penetrating oil-air fog—every moving part of cylinder or other air actuated device. Banishes destructive corrosion when machine is idle. Checks wear.

Installs easily into airline. Requires no change in basic machine design.

WRITE TODAY FOR COMPLETE INFORMATION.
C. A. Norgren Company, 222 Santa Fe Drive, Denver 9, Colorado.

Norgren

Solve Your Design, Fabrication and Delivery Problems by METAL SPINNING

"TEINER" offers Time and Money Savings

Metal spinning the "Teiner" way will enable you to simplify designs and speed up production. In small runs you can save the cost of expensive dies and castings.

"TEINER" is well qualified to be of assistance to you. As specialists in metal spinning for over fifty years, we are in position to offer valuable help in both design and production so that full advantage can be taken of the great savings possible through spinning, as well as the greater strength and finer quality of the parts produced. We are also equipped to fabricate commercial flange and disc heads.

An unusual and important part of "TEINER" service is the spinning of stainless steel. Here again, spinning eliminates the need for expensive castings and machining. It will be to your advantage to submit drawings or samples of your parts for a cost estimate of producing your requirements by spinning. Your inquiries are solicited.

Other "TEINER" Services

Stamping....Fabricating....Assembling....Soldering .... Silver Brazing ....Lacquering....Welding..etc. TEINER assures expert work in all metals and in any quantities, exactly to specifications. Our engineers are ready to cooperate with you on your needs.

ROLAND TEINER COMPANY

TEL. EVERETT 2669

130 TREMONT ST. EVERETT 99, MASS.

Custom Molding

INJECTION
COMPRESSION
TRANSFER

AT NORTHWEST Plastics

Large or Small Parts

When our engineers are called in at the very start—when they are consulted at the time that the product is still in the formative stage—our customers stand to get an improved product at lower cost. For plastics engineering can result in economies at every step. Northwest Plastics facilities include designing the product and mold (or working with your design department) . . . selecting the right materials . . . laboratory control . . . mold making by experts in our tool department . . . molding in our battery of presses . . . finishing and inspection on the assembly line . . . drop shipment service. Write for complete information.

We can serve you best if you consult us early.

NPW

NORTHWEST PLASTICS INC.

2237 University Ave. Saint Paul 4, Minn.

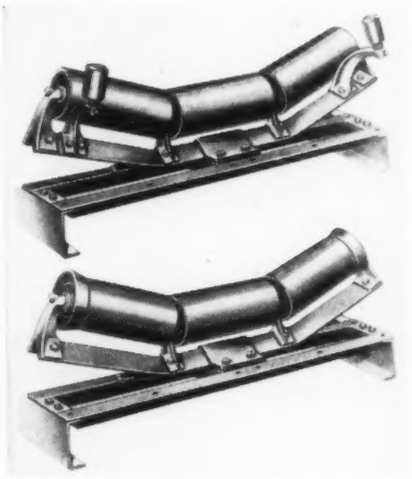
Chicago Office • 612 N. Michigan Blvd.

that can be advanced or receded. On other chain installations, much chain can be saved by using the Ultimate Double-Flex Chain method. This unit provides a continuous loop conveyor in oval, rectangular or offset form. The chain is looped around the power unit and take-up sprockets, but all other sections have a conveying surface.

Self-Aligning Idlers

The Jeffrey Mfg. Co., Columbus 16, Ohio.

Comprising a horizontal roller with inclined rollers on each side, these self-aligning idlers are for use with belt conveyor systems. Illustrated are the

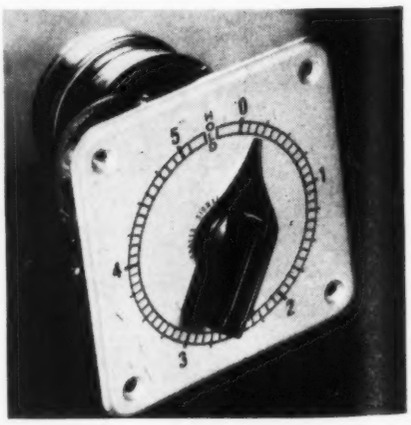


positive type self-aligning idler, above, with guide rollers, and, below, the self-aligning idler with flared, friction-type end pulleys. The latter are particularly adaptable for reversible belt systems.

Operation Timer

Eagle Signal Corp., 197 Harvey St., Moline, Ill.

For use on battery chargers, laundry equipment and all electrically energized machinery, this timer automatically stops the operation after the correct running time. The machine operation must be started manually. A synchronous motor times the operation and



2 GPM PUMP used instead of 100 GPM PUMP

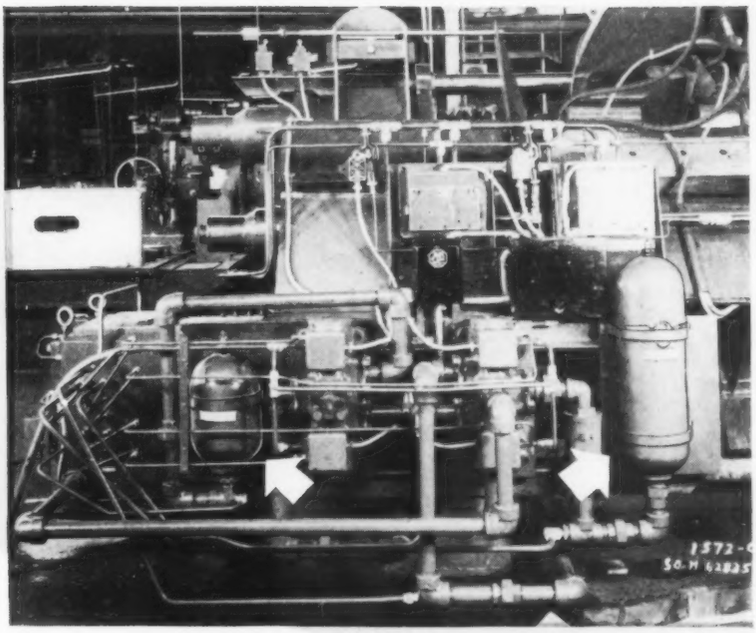


Photo courtesy of Progressive Welder Company, Detroit

THE "Progressive" flash welder shown here is a 500 KVA, hydraulically operated automatic welder used for welding large diameter steel shafts. Hydraulic power is used for automatic clamping, platen transverse and final upset.

Two GREER ACCUMULATORS release instantaneously the large volume of fluid at high pressure required for the operation of the welder. The accumulators permit the use of a relatively low capacity pump (2 gpm) whereas a pump of over 50 times this capacity (100 + gpm) would be required if the accumulators were not used.

Other advantages of the accumulators are simplicity, compactness and freedom from maintenance.

If you employ hydraulic power to do useful work, you too can profit by using GREER ACCUMULATORS. Write today for our booklet, "Hydraulic Power."

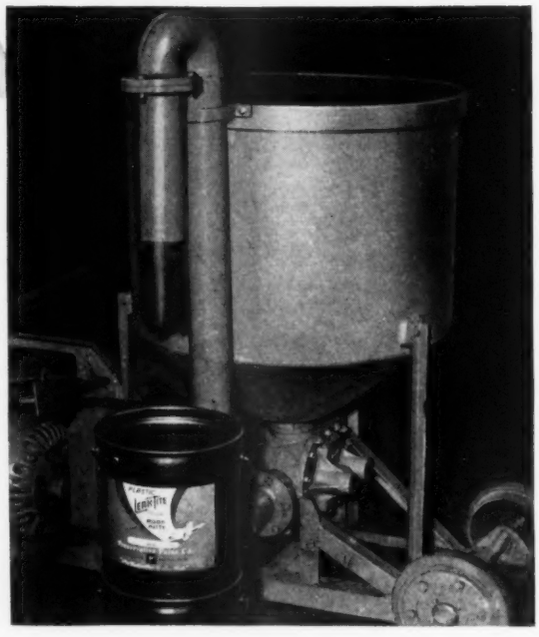
SALES REPRESENTATIVES

WATERMAN ENGINEERING CO.
721 Custer Ave., Evanston, Ill.
INDUSTRIAL EQUIPMENT CO.
170 Franklin St., Buffalo, N. Y.
ROGERS AND BAXTER
2013 Olive St., St. Louis 3, Mo.
LYTLE ENGINEERING CO.
4160 Mayfield Rd., Cleveland, Ohio
URQUHART SERVICE
1550 Blake St., Denver 2, Col.
MALESON COMPANY
5th and Chestnut Sts., Phila. 6, Pa.
RAMSAY PUMP & SUPPLY CO.
1104-8 Keenan Bldg., Pitts. 22, Pa.
PUMP EQUIPMENT & ENGINEERING CO.
238 Main St., Cambridge, Mass.
G. M. PEARSE, JR.
62 LaSalle Rd., W. Hartford, Conn.
JACK BREWER
1151 So. Broadway, Los Angeles, Cal.
PUMP ENGINEERING CO.
1331 3rd Ave., Seattle, Wash.
EBBERT & KIRKMAN CO.
321 Brown Marx Bldg., Birm'ham, Ala.
ARNOLD J. WERNER CO.
502 New Center Bldg., Detroit, Mich.
LLOYD T. GIBBS CO.
Petroleum Bldg., Tulsa, Okla.
POWER SPECIALTY CO.
1422 Niels Esperson Bldg., Houston 2, Texas
RUCKER VAUGHN CO.
4228 Hollis St., Oakland, Cal.
O'NEIL PUMP & ENGINEERING CO.
601 E. Franklin St., Richmond, Va.
ALEXANDER B. ANDREWS, JR.
Ins. Bldg., Raleigh, N. C.
JACK JEROME
5409-3 253rd St., Little Neck, L. I., N.Y.

"PATENT OLAER NUMBER 2256935"
"PATENT APPLICATION OLAER SERIAL NUMBER 519782."

GREER HYDRAULICS, Inc.
454 EIGHTEENTH ST., BROOKLYN 15, NEW YORK
WEST COAST OFFICE
359 S. ROBERTSON BLVD., BEVERLY HILLS, CAL.

Job time cut from 6 hours to ONE



Read What Mr. Burt Sheehan, Plant Engineer of the Preservative Paint Co., Seattle, Washington, says about their Roper Installation.

● "Our product, Plastic Leak-Tite, is a heavy roof putty for stopping leaks on asphalt roofs and around flashings. ● Containers were previously filled by hand with a putty knife and scoop. ● With the Roper Pump installation we now fill in one hour the same number of containers that were formerly filled in six hours. ● In addition to the saving of time, the operation is very much cleaner and neater."

SOLVING ONE OF THOSE "IMPOSSIBLE" JOBS!

Another example of Roper engineering solving one of those so-called "impossible" jobs . . . transferring a heavy viscous roofing compound at a maximum speed of 16 g.p.m.

The Roper Pump is mounted with a 3 h.p. motor, backgearing and 4-speed transmission on an Air Corps bomb truck so as to facilitate moving the equipment from one batch mixer to another.

Let Roper engineering help solve your pumping problems!

Send For Bulletin Get all of the facts on the Roper line. There is a model and size for nearly every industrial requirement. Capacities from ¼ to 300 g.p.m.; pressures up to 1000 p.s.i.

GEO. D. ROPER CORP.
381 Blackhawk Park Ave.
ROCKFORD, ILLINOIS

ROPER Rotary Pumps

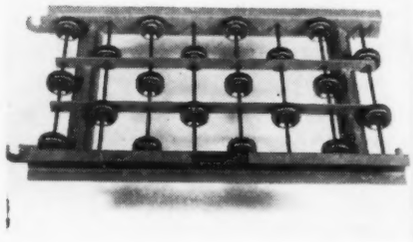
Sales Offices in Principal Cities

eliminates the need for escapements and springs. This timer mounts flush from front of panel and is designed to be built into machinery. Wires attach to screw terminals and need not be soldered. The operating contacts are made of silver and are designed for heavy duty service.

Gravity Wheel Conveyor

Sage Equipment Co., 30 Essex St., Buffalo 13, N. Y.

Straight line travel for all rigid containers has been brought about by the use of ball-bearing, zinc-plated wheels instead of the usual rollers. Of lightweight, welded-steel construction, the

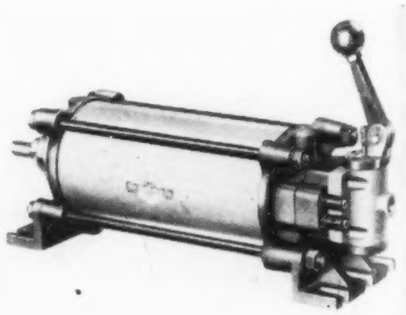


five or ten foot conveyor sections can be handled by one man. The sections can be hooked together without the use of tools. The wheels have bearing races with seven precision ground, ¼ in. ball-bearings. The sections are available in widths of 12, 14 and 18 inches.

Reciprocating Air Motor

Bellows Co., 222 W. Market St., Akron, Ohio.

A powerful reciprocating air motor, known as the BM15 ("B" for model, "M" for motor, "15" for developed piston thrust of 15 times air line pressure) embodies the Bellows integral valve design. The BM15 differs from conventional air cylinder construction in that the valve and all operating controls are integral with the unit. The valve-operating lever is adjustable to work from any angle in any plane. Easily adjustable controls, to regulate the speed of the piston in either or both directions, are integral with the motor itself, avoiding the necessity for adding special speed control valves to the air



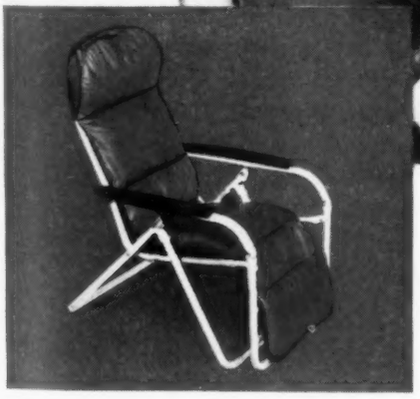
"This advertising message, appearing in 4-color cover position in BUSINESS WEEK and U. S. NEWS, is developing business for Monsanto Lustron molders and fabricators."

Molded by Worcester Moulded Plastics Co., Worcester, Mass., for Barcalo Manufacturing Co., Buffalo, New York.

when you use LUSTRON

A MONSANTO PLASTIC

finishing comes "FREE"



Finishing operations are practically eliminated, that's why so many cost-wise manufacturers select Lustron for their material today.

Expensive painting and enameling, with its several preparatory steps and multiple coats, plus necessary drying or baking is entirely eliminated. A Lustron product or part, when it pops from the mirror-bright surfaces of the die, is *molded and finished* in the single operation. The color is through-and-through; it can't peel, chip, crack or fade; the surface is sparkling clean and smooth.

For example, the manufacturer of this chair arm, with alternative material, would have paid for at least five separate finishing operations, plus cost of materials and inspection of each step.

At the same time he eliminated finishing costs with Lustron, he eliminated machining costs, and even the metal inserts were molded in. He enjoyed a full choice of colors, he got an arm with a pleasant, friendly "feel", his chair arm is resistant to alkalies, acids, water, it's sturdy and strong. And because Lustron's light in weight and low cost, too, he got more product for his material dollar.

If you are sharpening up your figures on production costs, it will pay you to look into Monsanto's versatile polystyrene, Lustron. We will be glad to send you complete Lustron data and, as always at Monsanto, a technical staff is on hand to help you with particular problems. Address: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield 2, Mass. In Canada, Monsanto (Canada) Ltd., Montreal. Lustron: Reg. U. S. Pat. Off.

MONSANTO
CHEMICALS AND PLASTICS

SERVING INDUSTRY . . . WHICH SERVES MANKIND

Silicone News

DC SILICONES

DC Silicone Fluid Solves Toughest Damping Problem

PHOTO COURTESY THE ELLIS SALES CO.

Constant Viscosity of DC 200 Fluid in Ellis "Contourliner" makes contour plowing easy and accurate.

A new, ingenious device made farm paper headlines recently when the Ellis Sales Company of Fairfield, Iowa, announced the "Contourliner"—an instrument for scientifically maintaining accuracy in contour plowing.

Previously it has been necessary for the farmer to survey his field, and put stakes along the contour line to serve as guide marks when plowing. The "Contourliner" eliminates all this extra work. Mounted on the hood of the tractor in plain view of the driver is an easy-to-read dial calibrated to show which way the tractor is deviating—to show how much in per cent of slope—to tell the driver which way to turn to get back on the contour.

Since tractors travel over extremely rough ground, a damping fluid was needed to prevent tractor vibrations from interfering with the accuracy of the instrument. The problem was to find a damping fluid that would retain a constant viscosity over a wide range of temperatures.

Many different types of oils were first tried as a damping fluid. Temperature variations, even during a normal summer day's operation, so changed the viscosity of these oils that accurate indication was impossible.

DC 200 fluid, suggested by Dow Corning engineers, proved to be the answer. Since DC 200 fluid has the ability to maintain almost unchanged viscosity from —40° F. to 400° F., it was of course unaffected by seasonal temperature changes. Stability under all types of conditions is a common characteristic of all Dow Corning Silicone products, including resins, varnishes, greases, and Silastic*, our silicone rubber. Dow Corning Silicone products are described in Catalog C 1-5.

*TRADEMARK DOW CORNING CORPORATION

DOW CORNING CORPORATION
MIDLAND, MICHIGAN

New York • Chicago • Cleveland • Los Angeles
In Canada: Fiberglas Canada, Ltd., Toronto
In England: Albright and Wilson, Ltd., London

Dow Corning

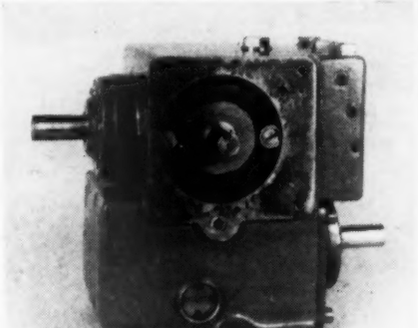
FIRST IN SILICONES

line. Only one air connection is required and that can be a flexible hose. The BM15 is precision-built with forged steel heads, heavy brass cylinder, stainless steel piston rod and corrosion-proofed piston construction for low friction loss. This unit is available from stock with stroke lengths of 1½, 3, 6 or 9 inches. The Model BM15, with its 4½ in. bore, develops a piston thrust of 15 times air line pressure, from any given line pressure up to 175 lb per sq inch.

Variable Speed Transmission

Portman Machine Tool Co., 70 Portman Rd., New Rochelle, N. Y.

This self-contained Variable Speed Hydraulic Transmission has a full neutral position and an infinite number of output speeds from the neutral to the electric driving motor speed. This multiple-

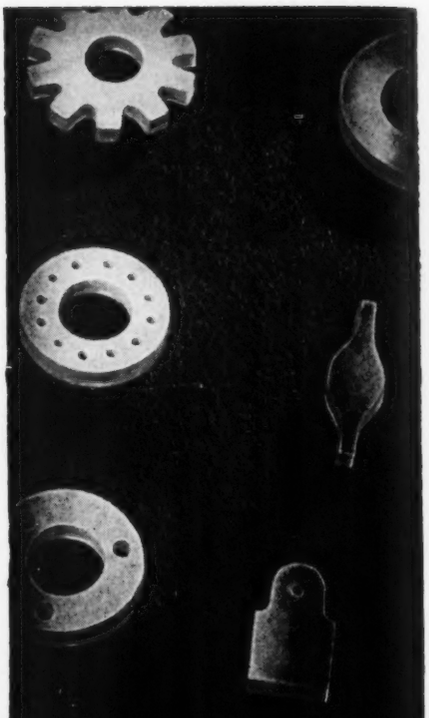


position, constant torque type transmission is available with various remote and manual controls. The over-all dimensions are 9¼ x 11 x 7 in. with shaft diameters of ¾ inches. The unit is rated up to 1 hp, maximum, with an output torque of 52½ lb-in., maximum.

Voltage Change Switch

P. R. Mallory & Co. Inc., 3029 E. Washington St., Indianapolis 6, Ind.

Making possible the universal application of frational horsepower motors, the Motor Voltage Change Switch is a line voltage setting device. One setting of the switch connects two field wind-



FELT PARTS CUT TO *precise* SPECIFICATIONS

Skilled operators and Booth-designed machinery combine to give you the utmost in accuracy of die-cut mechanical felt parts. Specifications are adhered to precisely. No deviations in size or thickness . . . the last felt part in any one lot is an exact duplicate of the first.

Prompt deliveries are routine at Booth and your order, small or large, receives interested attention.

●

APPLICATION CHART AND SAMPLE KIT... *contains swatches of S.A.E. felt types, with specification tables. Write for it. (No sales follow-up.)*

THE BOOTH FELT COMPANY

475 19th Street, Brooklyn 15, N. Y.
736 Sherman Street, Chicago 5, Ill.

2320

Booth
TRADE MARK

PRECISION CUT FELT PARTS

Compactness AND *Efficiency* of WOLVERINE TRUFIN

helped to make this PRESHON Cleaning and Degreasing Machine outstanding in performance

The Preshon Unit is a portable, cleaning device for removing paint, tar, grease, and other foreign substances from automobiles, farm equipment, buildings, etc.

Within its attractive housing is a heat exchanger made up of about 60 feet of Wolverine Trufin —THE integral finned tube— in the form of a compact coil. The Trufin coil replaced 200 feet of plain copper tubing formerly used in the unit, resulting in a great gain in operating efficiency, plus a gain in compactness.

The unit is capable of delivering 2½ gallons of 180°F water per minute, or up to 1½ gallons wet saturated steam per minute at a very low operating cost. Not only can Wolverine Trufin be subjected to such intense heat without damage but it will operate efficiently under those conditions —another qualification for THE integral finned tube.

This application—one of many from our customers' engineering files—demonstrates the widening uses of Wolverine Trufin. Perhaps your product can be more compact and made to operate more efficiently through the introduction of Trufin. Would you like to discuss the possibilities with our engineers?

WOLVERINE TUBE DIVISION

CALUMET & HECLA CONSOLIDATED COPPER COMPANY

MANUFACTURERS OF SEAMLESS COPPER & BRASS TUBING

1411 CENTRAL AVENUE • DETROIT 9, MICHIGAN

NTH DEGREE ACCURACY

...ONE INCH TO ONE MILE!

Precision Made Bourdon Gauge Tubing meets and beats most exacting requirements . . . performance tests.

Nth DEGREE LABORATORY CONTROL

"Precision Control" safeguards absolute accuracy of size of tube and wall thickness . . . plus the development of exact uniformity of the structure of the metal so essential to long life of pressure spring tubing.

Nth DEGREE HEAT TREATING

"Precision Control" in heat treating is achieved in exclusive bright annealing, atmospherically controlled furnaces. The precision exercised in attaining metallurgical specifications makes possible a tubing which is outstandingly high in fatigue resistance.

Nth DEGREE ACCURACY IN TESTING

"Precision Controlled" inspection carefully checks to the Nth degree every inch of tubing produced. Precision produces Bourdon Gauge Tubing to specifications with any non-ferrous metal. It is available in all bourdon shapes, in cut or random lengths. Obtainable on good delivery.

WHEN PRECISION COUNTS . . . COUNT ON PRECISION

Aluminum alloy instrument tubing to exact specifications . . . preformed tubing to suit your needs . . . Coaxitube—the metal shielded wire for a 1001 electronic uses. Write for complete catalog today.

PRECISION TUBE CO.

PRECISION

Factory: 3824-26-28 TERRACE STREET, PHILADELPHIA, PA.

ings in parallel for 110v operation, and the other position places the two windings in series for 220v operation. The switch is equipped with terminals that can serve as junctions for the line and field winding leads. The standard shaft is milled to fit 5/32 in. open-end wrenches. The shaft end can be machined to specification. The switch should only be used when the motor is under no-load conditions. It will withstand normal motor vibrations without changing positions.

Stiffness Tester

W. & L. E. Gurley, Troy, N. Y.

This motor-driven stiffness tester is used to show the degrees of stiffness for almost any thin flexible sheet material. The balanced pointer is pivoted on jewel bearings and moves concentric with a sine scale mounted on the base. The pointer is loaded 1, 2 or 4 in. below the pivot with a 5, 25, 50 or 200 gram weight. The arm carrying the standard dimension sample is moved by a small-geared synchronous motor that is controlled by a reversing switch on the

base. The greatest reading of the pointer against the sine scale is averaged in both directions, to eliminate effect of any curl, and is multiplied by the factor corresponding to the weight and distance combination used to give the stiffness of the sample. Finishes of varnish, paste, lacquer and other plasticizers can be tested on this unit. The capacity of the tester is from light tissue paper to the heaviest single sheet boxboards in common use. Light metal and metal foils can also be tested for stiffness.

Cam Yoke Roller Bearing

McGill Mfg. Co. Inc., Valparaiso, Ind.

The McGill Multirol Cam Yoke Roller Bearing is built with an inner race to increase adaptability where mounting with the conventional stud is undesir-

high ratios?

✳ ONE OF 93

DE LAVAL DOUBLE REDUCTION WORM GEARS

De Laval double reduction speed reducers, consisting of combinations of double worm gear reductions, or helical and worm gear reductions, are available with overall ratios up to approximately 8000 to 1. De Laval single reduction worm gear speed reducers are available in ratios up to 90 to 1. If high ratios are your requirement, worm gear speed reducers are the answer—particularly if space is limited and reliability is important. A De Laval representative will help you pick the right size and type.

✳ This double reduction De Laval Worm Gear Speed Reducer is available in many standard ratio combinations, with horizontal or vertical output shafts and is but one of 93 sizes of standard De Laval Worm Gear Speed Reducers.

DE LAVAL

***Worm Gear Division*—De Laval Steam Turbine Company, Trenton 2, N. J.**

Atlanta • Philadelphia • Charlotte • Pittsburgh • Cleveland • Rochester • Detroit • San Francisco • Chicago New York • Denver • Kansas City • Helena • Boston • Houston • Washington, D. C. • St. Paul • Los Angeles • New Orleans • Seattle • Salt Lake City • Tulsa • Edmonton • Winnipeg • Toronto • Vancouver

WG-14

TURBINES • HELICAL GEARS • WORM GEAR SPEED REDUCERS • CENTRIFUGAL PUMPS • CENTRIFUGAL BLOWERS AND COMPRESSORS • IMO OIL PUMPS

Unichrome Coatings offer you the Right Combination of properties for your product... every time!

AIR-DRYING LACQUERS seldom resist exposure and perspiration equally well. But often, that's just the combination you need for decorative hardware. The *right combination* also includes hardness, high gloss, extra adherence. Unichrome Coating A-112 supplies them all.

In fact, one lock manufacturer not only greatly improved his product with A-112's combination of properties, but actually saved production time. Its exceptional adherence eliminated his need for cleaning brass after buffing.

Whatever you make, chances are there's a Unichrome Coating that's *exactly right* for your product—for service requirements, for eye-appeal. It will pay you to look it up. Write us today on the properties you need in a coating, and we'll send you full information. No obligation, of course.

UNICHROME

Trade Mark Reg. U. S. Pat. Off.

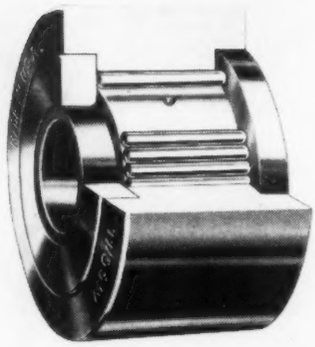
SYNTHETIC COATINGS AND LACQUERS

Products of

UNITED CHROMIUM, INCORPORATED

51 E. 42nd St., New York 17, N. Y. • Detroit 7, Mich. • Waterbury 90, Conn.

Chicago 4, Ill. • Dayton 2, Ohio • Los Angeles 11, Cal.



able. The internal construction of this bearing is similar to the Multirol Cam Follower in that it has a heavy outer race section and a full compliment of small diameter rounded-end rollers. The full useable length of the rollers provides maximum load carrying capacity. Bearings are made for shaft sizes from 0.250 to 1.25 inches.

Synchronous Motor

Gleason-Avery Inc., 27 Clark St., Auburn, N. Y.

Adaptable to large timing instruments, recording devices, dictating machines and others mechanisms requiring constant speed and high starting torque, the B-30-CS synchronous motor is now used in phonograph turn-table drives. It is similar in appearance and standard assembly to the B-30-A non-synchronous motor, but runs at a synchronous speed of 1,800 rpm. and has twice the number of laminations on large coils. Either standard or double-stacked motors can be wound for any normal a-c voltage and frequency.

Rotary Pump

Paul Engineering Co., Detroit 12, Mich.

A positive displacement pump, the Sundberg Rotary Pump Model 2-0 contains two moving parts. These rotors operate in the same direction with low friction loss. Because the rotors move against flexible synthetic rubber cushions, sand, grit and other abrasives flow freely through the pump without causing damage. The synthetic rubber is not effected by oil, kerosene or gasoline. This reversible pump will operate in any position and can be driven by a gasoline

CROFOOT GEAR SERVICE

Simplifies your problems in design and production

YOU DESIGN-WE PRODUCE PRECISION GEARS

OF ALL TYPES UP TO 12" DIAMETER

With the availability of Crofoot Service, design engineers need not be limited in developing new products or improving existing ones simply because their own plant does not have facilities to produce such gears as are required.

Nearly a quarter century ago the Crofoot organization recognized the fact that production of precision gears was a highly specialized field and set up the facilities necessary for this class of work. Crofoot can therefore effectively serve as the gear manufacturing department of any shop in the metal working industry. Gears up to 12" diameter in all types, can be produced efficiently, accurately and economically. Our engineers are also available to assist in gear design.

Ask for a "Crofoot" estimate on your gear requirements in any quantity. Send specifications and blue prints.

CHARLES E. CROFOOT GEAR CORP.

SOUTH EASTON, MASS.

full locking safety
—under heat or corrosion!

THERE'S NO deterioration, no weakening of the structure and locking security of the **An-cor-lox** lock nut under high heat.

And the gases and liquids encountered in process industry operation will not affect its efficiency. The complete seal produced by the flattened locking ring prevents passage of liquids and gases even under pressure.

A further advantage of **An-cor-lox** all metal construction lies in its adaptability to the use of special alloys for meeting extreme conditions of service. *Engineering data is available in our latest bulletin, which will be mailed you on request.*

2228

An·cor·lox
Lock Nuts

An-cor-lox Division
LAMINATED SHIM COMPANY, INCORPORATED
63 Union Street Glenbrook, Conn.

engine or an electric motor. Pump housing and drive pinion are bronze and the shaft is available in carbon or stainless steel. This pump has test-delivered 30 gpm at zero pressure and 26.4 gpm at 44 psi when driven by a 1 hp electric motor.

Pulsing Drive

Yardeny Laboratories Inc., 105 Chambers St., New York, N. Y.

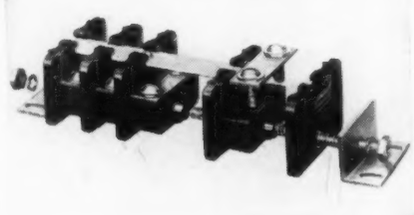
For controlling electrical motors when accurate positioning is desired, the Type B Pulsing Drive, responds to the operation of a single knob. When this knob is rotated, the pulsing drive selectively closes one of two circuits for very short

periods of time. The rate of repeating the opening and closing of the circuit is dependent upon the speed of knob rotation. Clockwise knob rotation turns the motor in one direction; counter-clockwise rotation turns the motor in the other direction. This unit, supplied in a standard steel inclosure, can be used to control motors up to 25 hp rating.

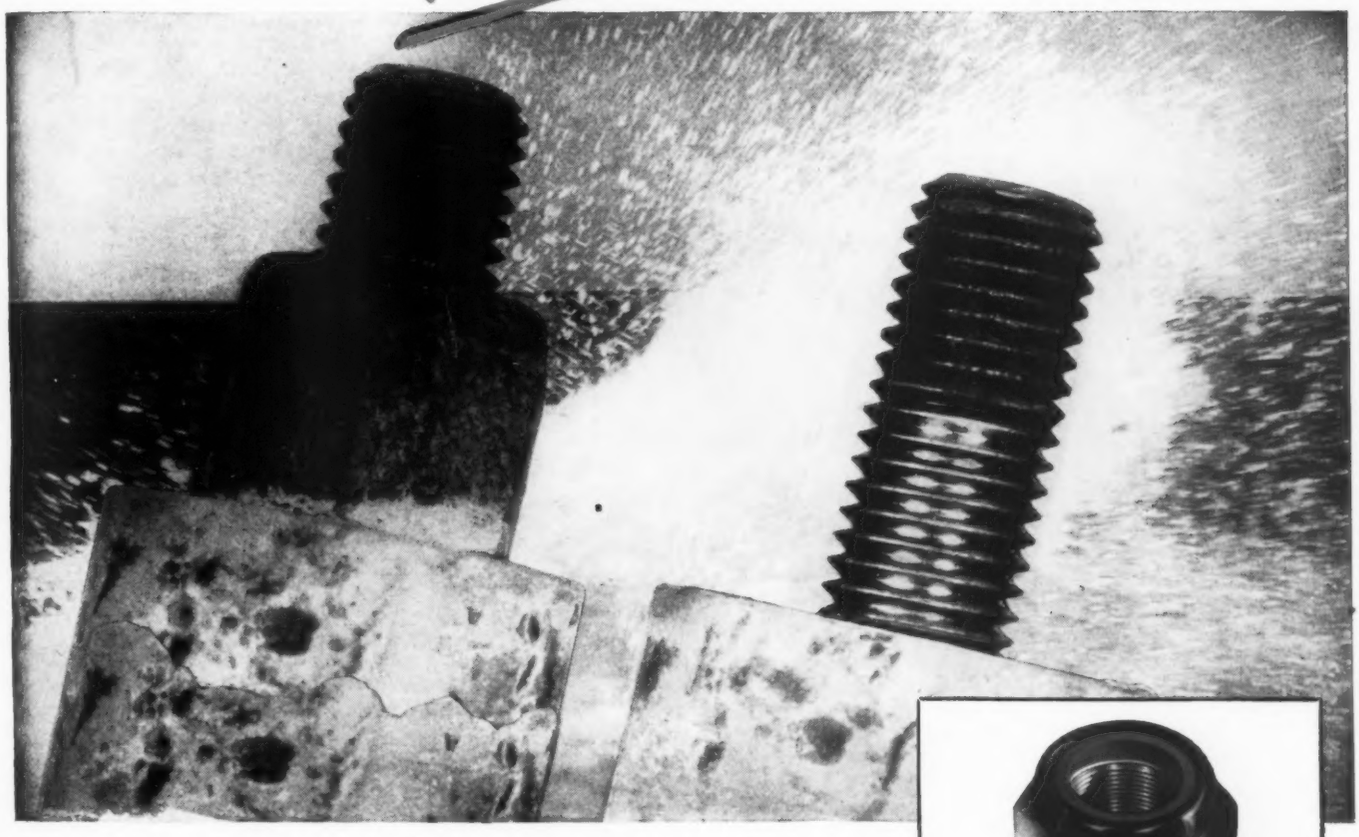
Terminal Block Kit

Curtis Development & Mfg. Co., 1 N. Crawford Ave., Chicago 24, Ill.

Units with any number of terminals from one to 14 can be made with the Type "B" kits. This individual built-up feature is suited for electrical engineers and others doing experimental work. The kits can also be used by maintenance departments where complete replacement units are not stocked. Kit No. 200 contains necessary molded sections, terminals and screw assemblies, and Kit No. 201 comprises end brack-



SELF-SEALING TO *Prevent Corrosion* OF BOLT THREADS



—with the Red Elastic Collar that protects the threads against Liquid Seepage

Moisture cannot penetrate the Red Elastic Collar. Study the heavily corroded bolt and nut assembly in the unretouched test photograph. It has been subjected to the equivalent of three years' exposure to moisture . . . to industrial smoke and grime . . . to climatic change. Study the same bolt with the nut removed. Look at the bolt threads that were inside the Elastic Stop Nut. They're as good as new! Why? Because the Red Elastic Collar protects them permanently against Liquid Seepage — and Corrosion. Elastic Stop Nuts are easily removed because they cannot 'rust solid'. They prevent fasteners from failing because of corrosion weakened threads.

Here's a challenge: Send us complete details of your toughest bolted trouble spot. We'll supply test nuts — FREE, in experimental quantities. For further information or literature address: Elastic Stop Nut Corporation of America, Union, New Jersey. Representatives and Agents are located in many principal cities.

ESNA

The RED ELASTIC COLLAR

— denoting an ESNA product —

. . . is threadless and permanently elastic. Every bolt — *regardless of commercial tolerances* — impresses (does not cut) its full thread contact in the Red Elastic Collar. This threading action produces a compressive, radial-reactive pressure against *both* the top and bottom sides of the bolt threads . . . insures a permanently tight, full contact between the bolt and nut threads . . . and makes all Elastic Stop Nuts self-sealing against Liquid Seepage.

As a result, all Elastic Stop Nuts protect permanently against thread corrosion.

ELASTIC STOP NUTS

INTERNAL WRENCHING

ANCHOR

INSTRUMENT MOUNTING

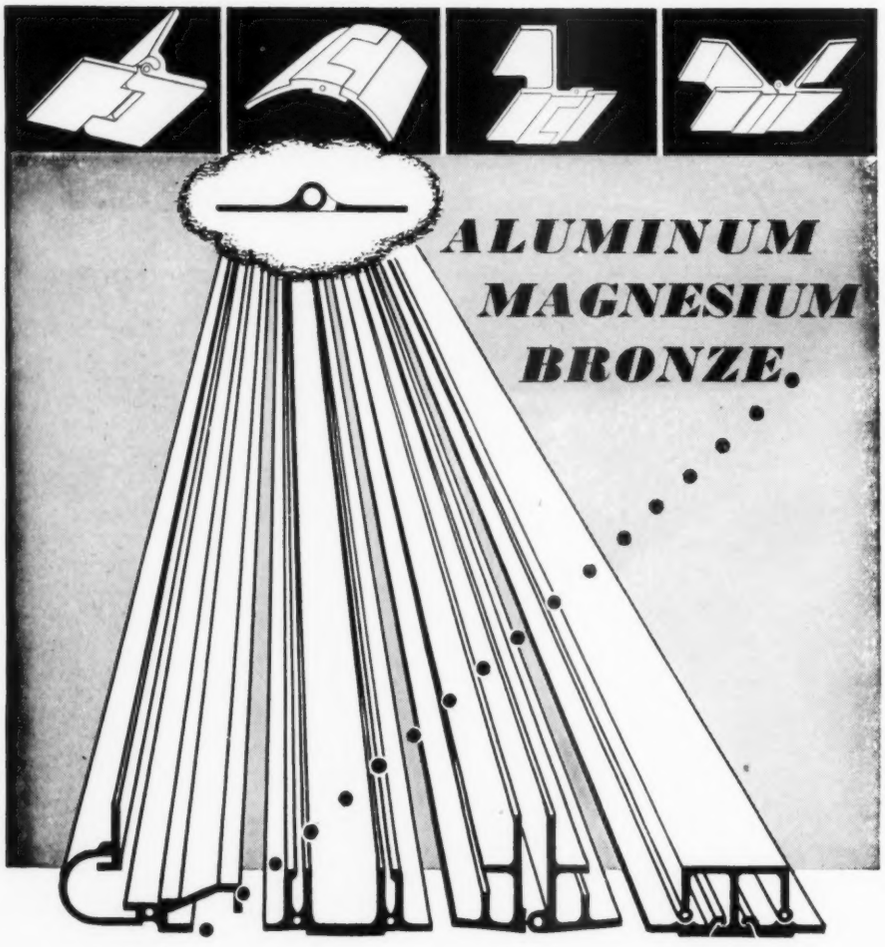
SPLINE

CLINCH

GANG CHANNEL

CAP

PRODUCTS OF: **ELASTIC STOP NUT CORPORATION OF AMERICA**



MOYNAHAN
FABRICATIONS

. . . Hinges for a Thousand Uses

There *is* an answer to your hinge or connector problem—Moynahan Fabrications. Moynahan engineers have developed hundreds of extruded hinges and connectors to meet customers' specific needs. They're available to you, too, in lengths from 0′1″ to 21′0″—in aluminum alloys, magnesium, bronze—in non-corrosive finishes, bright, or in colors to match any product.

Moynahan hinges and assembly connectors are *engineered* to your individual requirements for strength and appearance. Tested structural members—precision machined—with perfectly matched loops and spaces for universal interchangeability. Hinges, yes—but with a beauty dividend.

Many of the following products are designed to include Moynahan custom hinges and fabrications. They may suggest a solution to your hinge or assembly problem.

Aircraft
Displays
Music Boxes
Furniture
Trailers
Shipping Cases
Radios
Shower Doors
Railroad Cars
Luggage
Refrigerators
Light Fixtures

Our new catalog will prove of interest to your engineering department. Why not send for your copy today?

MOYNAHAN BRONZE CO., 9073 ALPINE AVENUE, DETROIT 4, MICH.

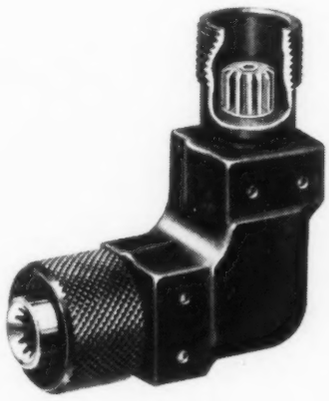
Designers & Manufacturers of INDUSTRIAL METAL PRODUCTS

ets, partitions, threaded rods, screws, nuts and washers. It is recommended that these kits not be used in installations where the temperature exceeds 400 deg Fahrenheit.

Flexible Shaft Adapter

F. W. Stewart Mfg. Corp., 4311-13 Ravenswood Ave., Chicago 13, Ill.

To provide a connection for a flexible shaft control where space limitations do not permit a junction without bending the shaft on too small a radius, adapter



No. 9100 is used. The right angle adapter, with its black anodized aluminum housing, weighs 0.141 pounds. The gear ratio is 1 to 1, and the unit requires a 2x1⅞x¾ in. space. This adapter has a torque capacity of 25 in-lb with a backlash of less than two degrees.

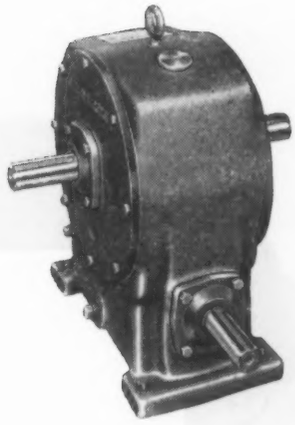
Valve Control

Shafer Valve Co. Inc., Mansfield, Ohio.

Shafer Valve Controls are used with valves that handle air, water, oil, gas and steam at high or low pressures, and at high or low temperatures. The illustrated valve is remotely controlled electrically with a circuit that requires but three wires leading to the solenoid. No current is required to maintain the valve in either open or closed position. Contact of one switch for a few seconds energizes the solenoid coil and opens the valve; contact of the other switch closes the valve. Other forms of this valve control can be actuated by pressure or instrument to give automatic valve operation. No exhaust is required to maintain valve in either open or closed position. A small amount of exhaust is vented as valve moves from closed to open. The valve is opened by line pressure and closed by a compressed spring. Valves can be supplied to operate at a pre-determined speed. The harmful effects of water hammer are avoided with this control because the speed of closing is self-governed by the com-

IN STOCK OR PROMPT DELIVERY

COMPLETE LINE Eberhardt-Denver WORM GEAR SPEED REDUCERS...

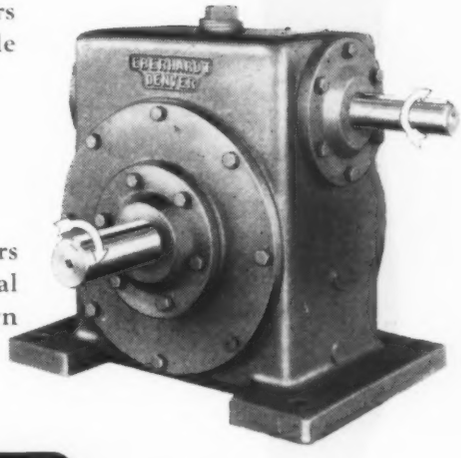


STANDARD ON-THE-SHELF LINE

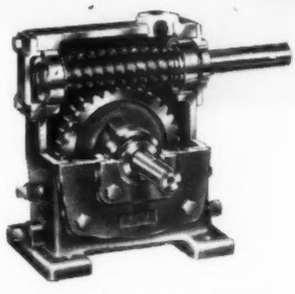
On many of your gear reduction applications you can take advantage of this standard line of small worm gear speed reducers . . . and save the time and expense of making special reduction units. These "In Stock" reducers are available in 29 models, single and double reduction, horizontal and vertical.

STANDARD OR CUSTOM BUILT HEAVY DUTY REDUCERS

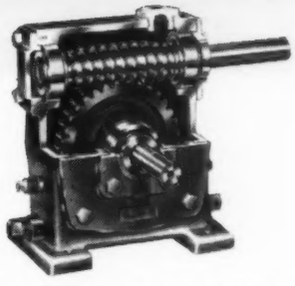
A standard line of 12 heavy duty reducers are available for prompt shipment, or special reduction units will be built to your own specifications.



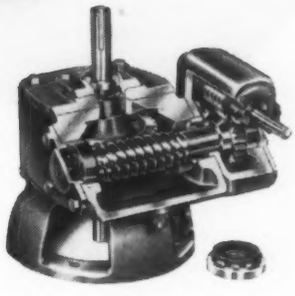
QUALITY REDUCERS



Worm and shaft are integral . . . worm is hardened, ground and polished.



Worm gear is made of high grade gear bronze with generated teeth.



Worm and gear shaft are carried on Timken tapered roller bearings.

QUALITY GEARS FOR 20 YEARS

Eberhardt-Denver Co.

1408 WEST COLFAX
DENVER, COLORADO

USE THIS COUPON

Gentlemen: Please send me your worm gear Speed Reducer Catalog and advise name of your distributor in this territory.

Name_____

Title_____

Company_____

St. or P. O. Address_____

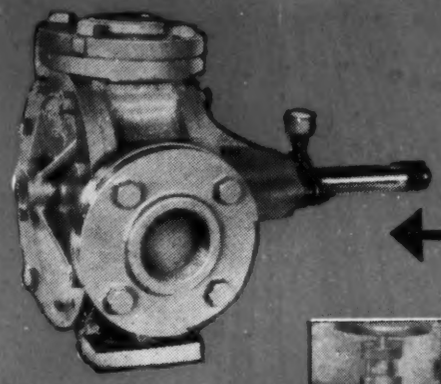
City_____ State_____

PE 1147

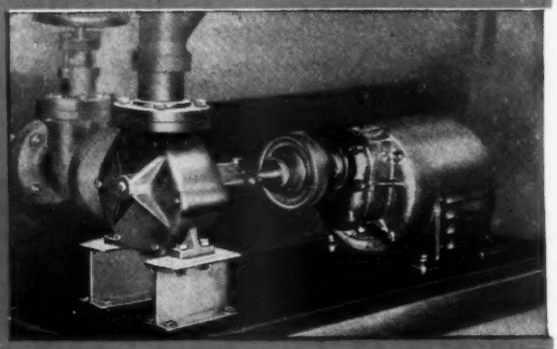
THIS IS THE FLUID

FLO-SWEET

AND THIS IS THE PUMP



AND THIS IS THE APPLICATION*



and This Is Why So Many Pumping Jobs Are Handled by Yale & Towne TRI-ROTOR

Positive handling characteristics and high volumetric efficiency are combined in one pump by means of the unique design of Yale & Towne's TRI-ROTOR rotary piston positive displacement pump.

It handles a wide variety of liquids — from volatile to viscous — without over-heating, chewing, foaming or agitating the product.

Only 3 moving parts (two pumping members) — minimum operating and maintenance expense.

Optional and interchangeable: Variable Volume Control (with or without Manual Flow Control), Integral Relief or By-pass valve, Solid Head.

New:
Pressure Regulator Device permits operator to adjust hydraulic mechanism to control *both* volumetric capacity and discharge pressure without stopping the unit.

Sizes: 5 GPM to 200 GPM for a wide variety of industrial applications (see coupon below).

ECONOMICAL—*Rotary Action*... PROTECTIVE—*Piston Action*...
ONLY YALE GIVES YOU BOTH IN ONE PUMP

TRADE YALE MARK

Pump Division of
THE YALE & TOWNE MFG. CO.
Stamford, Conn., U. S. A.
Representatives in Major Cities

Makers of the Famous Lines of Locks, Hardware, Hoists and Industrial Trucks

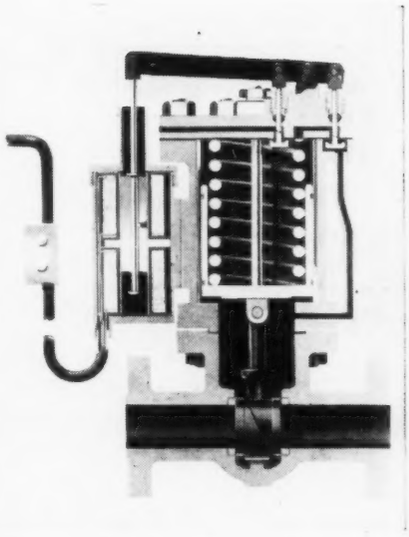
Wire or mail your requirements to Pump Division,
THE YALE & TOWNE MFG. CO., 212 Henry Street, Stamford, Conn., U. S. A.
The Yale & Towne TRI-ROTOR Pump is now in use pumping such products as these (check applications which interest you)

☐ Alcohol	☐ Fish Oil	☐ Lacquer	☐ Shortening
☐ Caustics	☐ Gasoline	☐ Liquid Soap	☐ Silicate of Soda
☐ Chocolate	☐ Glucose	☐ Molasses	☐ Solvents
☐ Coolants	☐ Greases	☐ Oils	☐ Starch
☐ Corn Syrup	☐ Ink	☐ Paint	☐ Varnish
☐ Edible Oils	☐ Honey	☐ Propane	☐ Viscose

NAME .....

COMPANY .....

CITY ..... Zone ..... State

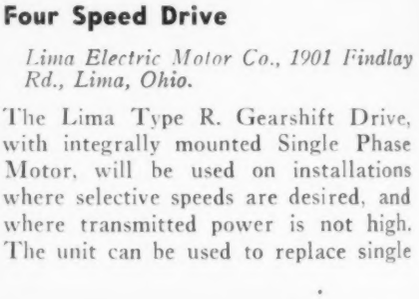


pressed spring. These controls are available for the operation of valves from 1 in. up, and for pressures ranging from 25 to 6,000 pounds. Because the solenoids are not energized for long periods of time, the control will operate on 110 or 220 v a-c or d-c current. These controls are used on gate, angle, globe and other types of screw operated valves.

Four Speed Drive

Lima Electric Motor Co., 1901 Findlay Rd., Lima, Ohio.

The Lima Type R. Gearshift Drive, with integrally mounted Single Phase Motor, will be used on installations where selective speeds are desired, and where transmitted power is not high. The unit can be used to replace single



phase equipment now used, and can be used as an integral part of machines now building. These drives will operate on 115 and 230 v a-c, 50 and 60 cycle. Gear ratios of these units are 1 to 1, 1.33 to 1, 2 to1 and 4 to 1 for both ½ hp, 1,200 rpm, and ¾ hp, 1,800 rpm capacities.

Airport Caster

The Bassick Co., Bridgeport, Conn.

The steel coiled spring, over six feet long, of the Floating-Hub wheel, is built into the hub in such a way that it carries the load off center and levelizes

BUT a gal's lucky to get even one in some parts of the country. The water is so hard it's necessary to use water softeners. The operation of many softeners is timed with Telechron synchronous electric motors.

This application is typical of the unusual jobs being found every day for these versatile motors. They have been used successfully in clocks and timing devices for 25 years—and more. They have given dependable service in automatic timing, switching, recording and control equipment. Chances are a Telechron motor is the answer to your own needs.

These accurate, self-starting motors can be adapted to complicated control mechanisms as readily as to simple switches. They reach rated speed almost instantly and operate in perfect synchronism on all commercial frequencies . . . *can't run faster or slower.* Torque ratings are conservative. Precision building and Telechron's exclusive sealed-in oiling system assure years of accurate service.

With a Telechron motor, you get all the advantages of pioneering research and engineering leadership. For over 25 years, Telechron has been the largest producer of synchronous electric motors. And every Telechron motor is Underwriters Laboratories approved under reexamination service. Telechron application engineers will be glad to talk over your needs. Address Motor Advisory Service, Dept. D, Telechron Inc., Ashland, Massachusetts.

see our CATALOG in SWEET'S FILE for PRODUCT DESIGNERS

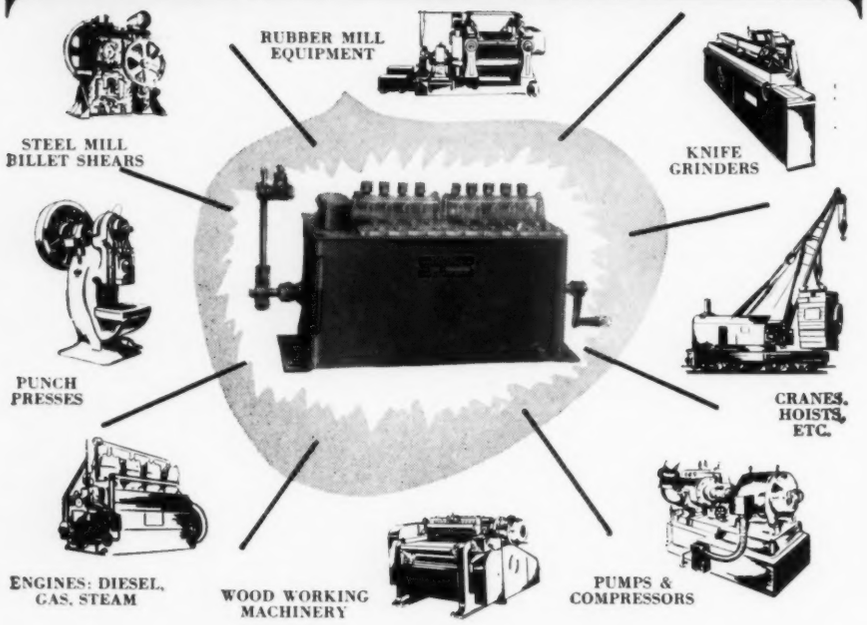
Telechron Motors Are Now Being Used for:

Stoker, Oil Burner and Temperature Controls
Industrial Process and Cycling Timers
Business Machinery
Medical Devices
Household Appliance Timers
Musical Devices

Telechron
REG. U. S. PAT. OFF.
SYNCHRONOUS MOTORS

The first and favorite synchronous electric timing motor

A FEW OF THE MANY USES FOR
MANZEL LUBRICATORS



Manzel Force Feed Lubricators efficiently, dependably lubricate *ANY* type of equipment. Manzel engineers will gladly make recommendations.

Manzel Brothers Co. now supplies repair parts for all models of Bowser and Torrington Lubricators.

Builders of HIGH PRESSURE METERING PUMPS Since 1898

A Subsidiary of Frontier Industries, Inc.

Manzel BROTHERS CO.

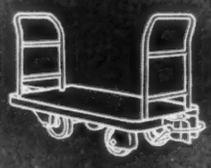
338 Babcock Street Buffalo 10, N. Y.

EWC WHEELS

Engineered for YOUR Product

There is a wide variety of EWC wheels and axles for every type of mobile equipment . . . one or several may be ideally suited to your product. For unusual wheel problems, we offer you a complete engineering service, with a thoroughly experienced staff and unexcelled facilities. Write today for complete information.

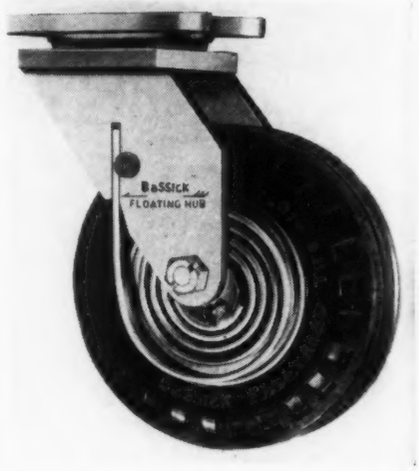
EWC Industrial Trailers


Model No. 1002 Caster Trailer

Model W-3 3-Ton Capacity

Model WP-5 5-Ton Dump Trailer

ELECTRIC WHEEL CO., Quincy, Illinois, Est. 1890

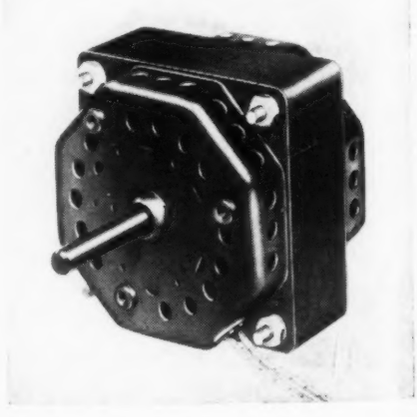


the axle's line of travel. The wheel stays in contact with the ground, rather than bouncing up and down, and it rides over bumps without lifting the load. These caster wheels have been used on airport cargo tubs, but can be used on all types of portable equipment. They have increased the moving speed of cargo tubs from 15 to 25 mph without increases in vibration. It is claimed that tubs built with these casters are not subject to bounces, shocks or shimmy, and that they minimize damage to cargo. The spring suspension hub is available in many sizes and types of casters and wheel mountings. The Bassick Floatread tire used with these casters has a specially designed tread to provide maximum floatation and to prevent the wheel from digging into soft ground. The tire has no innertube and requires no pumping.

Small Motors

The Alliance Mfg. Co., 100 Lake Park Blvd., Alliance, Ohio.

The Model B Powr-Pakt Motors are used as the power sources for driving fan blades, magnetic tape, disk and wire recorders, and similar devices. When used as shown, these semi-inclosed, four-pole, shaded pole induction motors need no external cooling. Various horsepower ratings can be obtained de-



Dillon-Beck finds Acetate the best!

Fish lures and hook pack molded by Dillon-Beck Mfg. Co., Hillside, N. J., from cellulose acetate supplied by Chemaco Corporation.

WHEN fishing tackle manufacturers require plastic moldings, many of the leaders go to Dillon-Beck Manufacturing Company. Dillon-Beck, in turn, uses *cellulose acetate* plastics *exclusively* for such applications.

For fish lures and other anglers' accessories—as for hundreds of other applications, cellulose acetate is used primarily for its outstanding toughness and durability.

These qualities may be judged many ways. In addition to withstanding hard knocks in use, cellulose acetate is economical—by eliminating breakage during manufacture and assembly. Fast and easy to mold, cellulose acetate can be drilled, threaded, and machined without shattering.

The dimensional stability of cellulose acetate (better than ever in new formulations) also contributes to the durability of acetate moldings. Closely-fitting parts may be formed to precision dimensions, and metal inserts may be embedded, with assurance that these components will not loosen in service. Moisture resistance of the material is obvious from this application.

Cellulose acetate was selected also for its permanent finish, its wide range of colors, and the crystal-clear effect required in the body of the lures. All together, these properties indicate why more and more manufacturers of products ranging from vacuum cleaners to electric switches specify the cellulosics.

While Hercules does not make cellulosic plastics or molding powder, we will be glad to send you helpful technical literature on the Hercules base materials from which they are made.

HERCULES POWDER COMPANY
904 Market Street, Wilmington 99, Delaware

CP7-11

Save and Sell with Cellulosic Plastics

CELLULOSE ACETATE • ETHYL CELLULOSE • NITROCELLULOSE

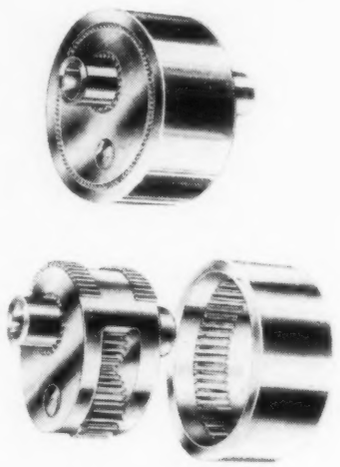
Now!
FORGED STEEL
THE LATEST DEVELOPMENT IN
CHIKSAN
BALL-BEARING SWIVEL JOINTS
CHIKSAN has adopted forged steel for all Styles and Sizes to and including 2"...in the following pressure ratings: 1,000 psi, 3,000 psi, 12,000 psi and High Temperature (700 psi, 500° F.). This important development now brings even higher quality to CHIKSAN users everywhere. It is tangible evidence of CHIKSAN's policy for continuous development in the design and manufacture of Ball-Bearing Swivel Joints for all purposes.
CHIKSAN REPRESENTATIVES IN PRINCIPAL CITIES
EXCLUSIVE EXPORT REPRESENTATIVE: CHIKSAN EXPORT CO., Brea, California
Branches: New York 7 — Houston 1
CHIKSAN
TRADE MARK
BALL BEARING SWIVEL JOINTS FOR ALL PURPOSES
CHIKSAN COMPANY
BREA, CALIFORNIA
New York 7
Houston 1

pending on the lamination stack thickness. The starting torque is approximately 40 percent of the torque at the full load rating. The motor is rated as 1/70 hp at 1,600 rpm when operated on 115 v, 60 cycle frequency current.

Epicyclic Drive

American Brake Shoe Co., 230 Park Ave., New York 17, N. Y.

Providing a simple and efficient means of converting high rotating speeds into slow reciprocating motion, this epicyclic drive is built as an integral unit on antifriction or plain bearings. Test data on compressors and hydraulic pumps have shown greater efficiency than units with the more conventional methods of belting or gearing. Design of the drive

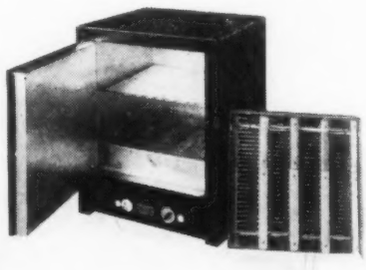


permits considerable flexibility in both speed and stroke, making possible the use of built-in or direct drive input power. Where synchronous speeds are not required, rolling members can be substituted for the gears, offering greater manufacturing economy.

Electric Oven

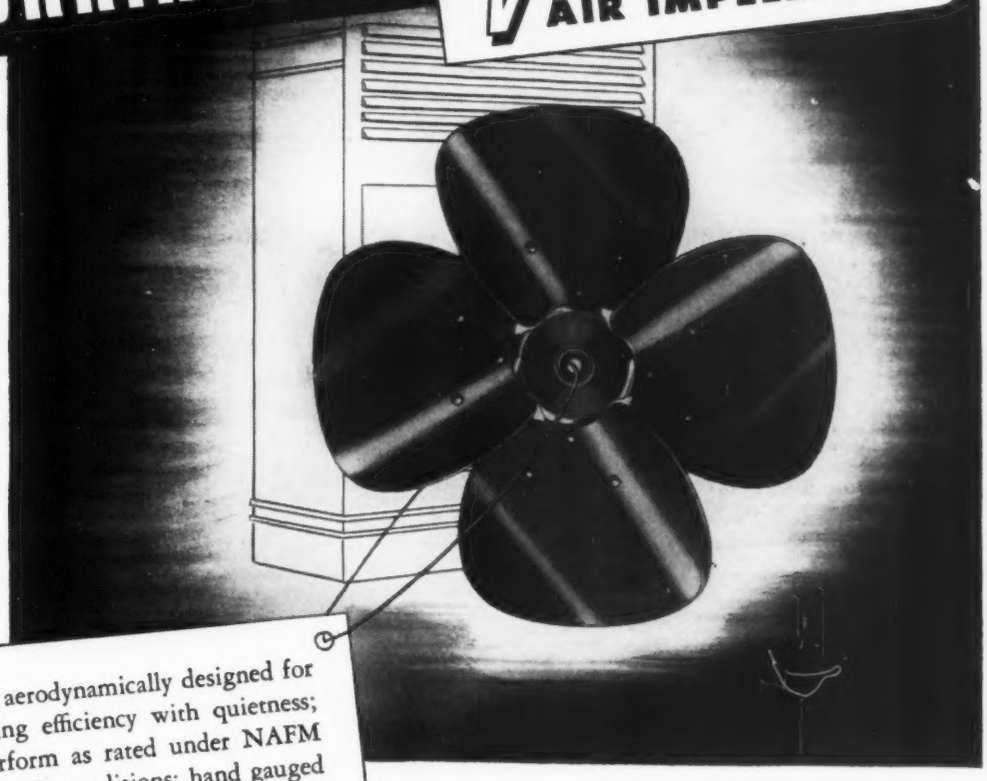
Trent Inc., Philadelphia, Pa.

This automatic electric oven is designed for use in bonding brake linings to brake shoes in 30 min without the use of rivets. The liner is clamped to the shoe with a bonding of plastic between. The



QUIETER with TORRINGTON

Vairified* AIR IMPELLERS



*Vairified . . . aerodynamically designed for maximum operating efficiency with quietness; guaranteed to perform as rated under NAFM and NEMA Test Code conditions; hand gauged for uniform contour, alignment and balance. The Torrington Manufacturing Company.

Fan blades may look pretty much alike, *but there's a big difference in their operating characteristics,* as a condenser manufacturer discovered to his satisfaction.

For his otherwise highly acceptable product, an excessive noise level spelled trouble ahead. Sound measurements of his unit, taken in a live room, with a competitive fan blade operating, showed the noise level to be 78 decibels. Torrington engineers then substituted an Airistocrat Fan Blade and noise level fell to 70 decibels — or from 14,000 to 8,000 units of loudness. For this type of unit, this was fully satisfactory performance.

But simple corrections like this are not always possible. That's why we strongly urge you to consult Torrington engineers while your product is in the early stages of design. Maximum efficiency in the use of forced air is thus assured.

THE **TORRINGTON**

MANUFACTURING COMPANY, TORRINGTON, CONNECTICUT

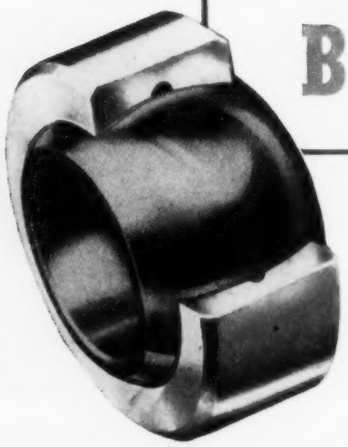
AIRISTOCRAT FAN BLADES • AIROTOR BLOWER WHEELS • IMPROVE PRODUCT PERFORMANCE

THE NEW

HALFCO

SPHERICAL CONTACT SELF-ALIGNING BEARING

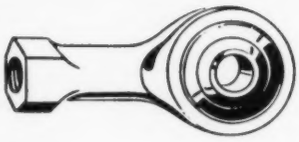
U. S. AND FOREIGN PATENTS PENDING



Here's a new, two-piece, self-aligning bearing. It consists of a heat-treated, hard-chrome-plated, highly-polished steel ball, around which an outer race is integrally formed. This unique design permits the greatest possible mis-alignment. Full *spherical surface* contact allows extremely heavy loading—resists both axial and radial forces.

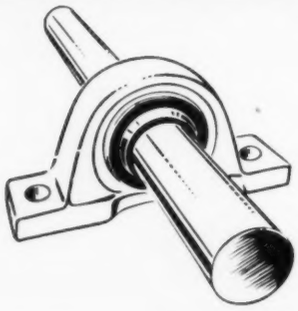
Here are a few of the countless applications for HALFCO Bearings—

AS A ROD END BEARING



The self-aligning and shock resisting characteristics of HALFCO Bearings make them ideal for mechanical linkage systems. They may be used as ball joints, rod ends on actuating cylinders, or on linkages to accommodate motion in more than one plane.

AS A ROTATION BEARING OR STATIC, SELF-ALIGNING BUSHING



HALFCO Bearings have wide applications as rotation bearings for high load, slow speed installations. The self-aligning and axial thrust capacity features make them far superior to plain journal bearings for certain applications. A 360 degree oil groove assures positive lubrication.

The extremely high permissible loading on the HALFCO Bearings makes them well suited for static, self-aligning bushing service. HALFCO units are also used as engine mount attachment bushings where heavy loading and easy removal of supported unit are important.

ADEL

The simplicity of design permits low cost, volume production methods to be utilized. HALFCO Bearings are fabricated in a wide variety of materials, types and sizes. Consider them for your application. Write for catalog containing complete specifications.

Please address inquiries to

10757 Van Owen Street, Burbank, California.

ADEL PRECISION PRODUCTS CORP.

BURBANK, CALIFORNIA ★ HUNTINGTON, WEST VIRGINIA

Manufacturers of: Aircraft Hydraulic Systems • Marine & Industrial ISOdraulic Controls • Halfco Self-Aligning Bearings • Line Support Clips & Blocks Industrial Hydraulic Equipment • Aircraft Valves • Industrial Valves

assembly is then heated to 350 deg Fahrenheit. A thermostat holds the oven temperature constant. Trent "folded-and-formed" heating elements are used. The oven is 20x20x20 in. and is rated at 3kw on 110 or 220v single phase current.

High Impact Die Steels

Latrobe Electric Steel Co., Latrobe, Pa.

Four new high carbon, high chrome grades of Desegatized brands of dispersed segregate die steels are said to have high impact strengths. In these steels, an even dispersion of free carbides is achieved in the body of the steel, avoiding a brittle central mass. This quality is claimed to give a more uniform bar with less warpage and breakage, and more consistent results under heat-treatment. The grades now manufactured are: Select B, modified chrome air hardening; G.S.N., high carbon, high chrome oil hardening; Olympic, high carbon, high chrome air hardening; and Cobalt Chrome, special high carbon, high chrome, cobalt air hardening. An unusually high impact strength has been established in exhaustive testing, as indicated by the following table of comparative impact values of samples heated to the most effective usable hardness for maximum working efficiency:

Die Steels	Hardness Rock. C	Impact Strength, ft-lb	
		Old process	New process
Select B	62.0	69.5	50.0
G.S.N.	59.5	25.0	22.0
Olympic	60.0	70.0	61.0
Cobalt Chrome	60.0	55.0	44.0

Silicone Oils

Dow Corning Corp., Midland, Mich.

A series of silicone oils, designated Type DC 710, are used for high temperature lubrication, especially in timing mechanisms, precision instruments and oven conveyors. These oils have high heat stability combined with high resistance to oxidation, freedom from gumming, water repellency, low volatility and high flash points. Two of the DC 710 oils are especially designed for high temperature lubrication. One, DC 710 R, contains a corrosion inhibitor and provides permanent lubrication for sealed-in devices; the other, DC 710 G, containing colloidal graphite in suspension, lubricates mechanisms continually exposed to extreme heat, weather or high humidity. Silicone oils of this series can be used at temperatures ranging from 10 to 500 F, and are used for high temperature baths and hydraulic fluids.